THE AUGUST SCIENTIFIC MONTHLY

Edited by

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CONTENTS

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NEW BOOKS OF SCIENTIFIC INTEREST

Chemistry. GERALD WENDT. Illustrated. ix + 300 pp. $2.25. 1942. Wiley.

This is one of a series of scientific textbooks whose purpose is to furnish a background in the various sciences upon which students may build future knowledge. It embodies a selection of the principles considered by the author to be the most important and far-reaching in modern life. It is not intended for the training of professional chemists.

The Technology of Natural Resins. C. L. MANTELL, C. W. KOPF, J. L. CURTIS, E. M. ROGERS. Illustrated. vii + 506 pp. $7.00. 1942. Wiley.

This volume discusses damar, copal, East India and related resins from the viewpoint of their properties, applications, industrial uses, development and technology. It is intended to give a technical background for those interested in commercial resins of natural origin.

Earth Sciences. J H. BRETZ. Illustrated. viii + 260 pp. 1940. Wiley.

One in a series of scientific textbooks, this work takes up in condensed form the studies of geology and oceanography; the effect on the earth of rivers, winds, seas, volcanoes, etc. The text is accompanied by numerous illustrations and diagrams prepared by the author's son.

Pain. T. LEWIS. xiii + 192 pp. Illustrated. $3.00. 1942. Macmillan.

The chief purpose of this book is to review modern ideas of the mechanism of human pain and to bring into perspective with other observations the work of the author's laboratory during the last ten years. It is intended as a reference book and is accompanied by illustrations and diagrams.

Introduction to Human Physiology. L. A. CRANDALL. Illustrated. xii + 388 pp. 1942. Saunders.

The aim of the author of this textbook is to impart a general knowledge of how the body functions and how the study is applied. Examples from everyday life and diagrammatic pictures showing the workings of the body systems are used to simplify the subject matter.

Plant Biology. P. WEATHERWAX. Illustrated. vi + 455 pp. $3.25. 1942. Saunders.

This textbook is designed primarily for one-semester courses in elementary botany and for the botany part of general biology courses. The subject covers a treatment of cell structure and function, sources and utilization of food, and the nature of leaves, roots and the soil. Diagrams, index and glossary are included.

The American Pocket Medical Dictionary. W. A. N. DORLAND, ed. 17th ed. 1037 pp. $2.50. 1942. Saunders.

This small volume is intended to fill the need for a pocket dictionary which, though handy in size, is supposed to be sufficiently complete to supply the wants of the practising physician as well as those of the student of medicine. Several tables have been included.

The Varieties of Temperament. W. H. SHELDON. Illustrated. x + 520 pp. $4.50. 1942. Harper.

This deals mainly with the interrelation between morphological characteristics and the more dynamic levels of personality. The total aim is to describe and interpret the most deep-seated pattern of the individual personality. The volume is the second in a series.

The Changing Physical Environment of the Hopi Indians of Arizona. J. T. HACK. Illustrated. xxii + 85 pp. $1.75. 1942. Peabody Museum.

This monograph is the first of the final reports of the Peabody Museum Awatovi Expedition. It discusses the modern environment and inhabitants of the Hopi country, the physical basis for their agriculture, sand dunes and climatic changes, erosion and sedimentation.

Airways. H. L. SMITH. Illustrated. xxix + 430 pp. $3.50. 1942. Knopf.

This work presents a history of commercial aviation in the United States. The author considers the growth of American aeronautics as a condensed and romanticized parallel to that of the railroads with the additional advantage to an historian that most of the pioneers of commercial aviation are still living.

Dr. Bard of Hyde Park. J. B. LANGSTAFF. Illustrated. 365 pp. $3.75. 1942. Dutton.

This is a biography of one of George Washington's physicians and is also intended as a portrayal of the professional and social life of the time. It discusses the ways of early medicine, the life of Old New York and of the Old Hudson River Colony as well as early student days in Edinburgh and London.

Plant Hunters in the Andes. T. H. GOODSPEED. Illustrated. xvi + 429 pp. $5.00. Farrar and Rinehart.

This book describes the landscapes, peoples and customs, as well as the remarkable vegetation of the Andes on the West Coast of South America. It is intended for both the amateur or professional botanist and the interested layman.

The Social Life of a Modern Community. W. L. WARNER and P. S. LUNT. Illustrated. xx + 460 pp. $4.00. 1941. Yale.

The authors write of a class hierarchy in which the people of the American town are distributed through six social strata, with most of the social behavior influenced by class factors. The volume is the first in the six-volume "Yankee City Series."

Famous Explorers for Boys and Girls. R. P. COFFMAN, N. G. GOODMAN. Illustrated. 166 pp. $2.00. 1942. A. S. Barnes.

The aim of this book, a collection of biographies of explorers from Marco Polo to Admiral Byrd, is to depict historical figures and events in such a way that the reader will be encouraged to study further. Each biographical sketch is preceded by a contemporary portrait.

THE SCIENTIFIC MONTHLY

AUGUST, 1942

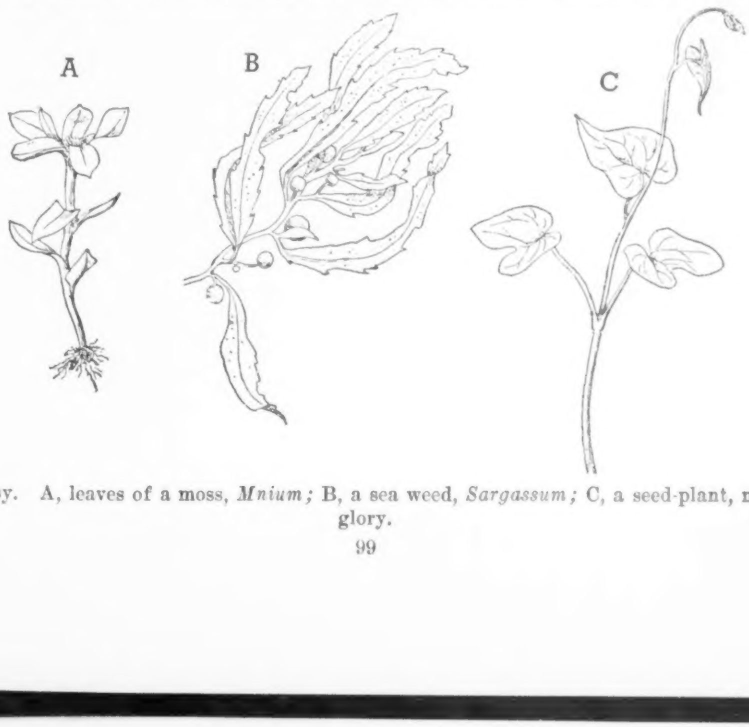
EVOLUTION OF THE LAND PLANTS

By Dr. D. H. CAMPBELL
PROFESSOR OF BOTANY, STANFORD UNIVERSITY

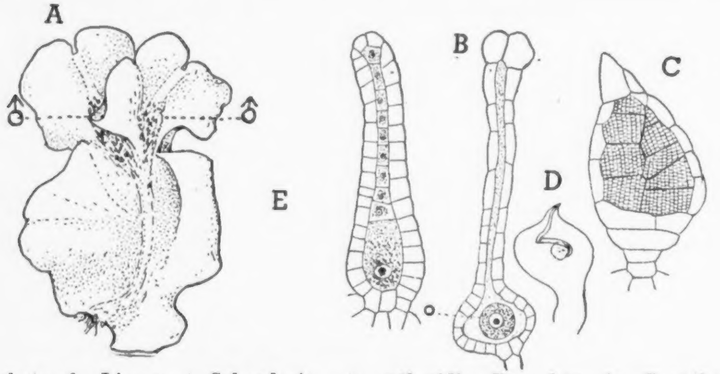
PLANT structures are much more uniform than those of animals, and it is hardly possible to establish such definite major divisions as are recognized in the Animal Kingdom. Where specialized tissues like the woody, skeletal structures of the higher plants are found, they are much less constant than those of animals, so that they are less reliable indicators of genetic relationship. The higher plants are also much less individualized than are most animals. An oak, for example, is a colony of potential independent plants rather than a true individual.

The higher plants, on the whole, are more conservative than are the higher animals. Thus many existing genera of flowering plants, *e.g.*, sassafras, poplar, are represented by fossil species at a period when the modern families of birds and mammals had not come into existence.

In seeking relationships among any groups of organisms it is in the simpler members of the groups that the resemblances are most evident. The highly specialized forms are usually the ends of definite phyla. Primitive characters, however, may persist in some of the most successful living types. Thus the anthers of the flowering plants are structurally much like the sporangia of some of the primitive ferns, and the development of the pollen grains (spores) is in no way essentially different from the spore-division of the simplest liverwort.



Homoplasy. A, leaves of a moss, *Mnium;* B, a sea weed, *Sargassum;* C, a seed-plant, morning-glory.



A, Gametophyte of a Liverwort, *Calycularia*. ♂, antheridia; B, archegonia; C, antheridium, of *Riccia*; D, spermatozoid of *Riccia*.

A comparison of the structure and development of the organs of plants may furnish a clue to the degree of relationship. Where the corresponding organs in the plants are shown to be genetically related, the organs are "homologous." Similar organs, *e.g.*, leaves, may occur in totally unrelated forms, such as algae, mosses and flowering plants. These similar but independently developed organs have been called "homoplastic."

All plants below the mosses (Bryophytes) are still treated in some current text-books as members of a single primary division, or sub-kingdom, Thallophyta. Within the Thallophyta are included plants ranging from microscopic bacteria and unicellular algae to massive fungi and giant sea-weeds of very complex structure. The inclusion in a single sub-kingdom of such a heterogeneous assemblage of obviously unrelated types is certainly far from scientific. While the term thallophyte might be retained for convenience, as zoologists use the term "invertebrates," in neither case should these imply a natural assemblage.

On the other hand, the three primary groups of green land plants, *viz.*, Bryophytes (mosses), Pteridophytes (ferns) and Spermatophytes (seed plants), often considered as sub-kingdoms, all agree in their essential reproductive structures. There is ample reason for uniting these three groups into a single sub-kingdom, Embryophyta, as proposed by Engler in his synopsis of the families of plants.

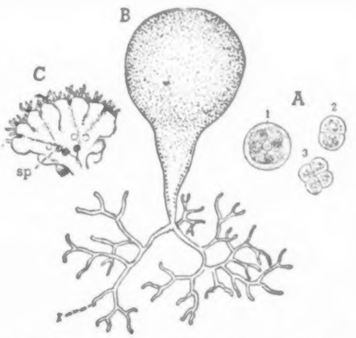
The usual division of the Embryophytes into Bryophytes, Pteridophytes and Spermatophytes is a somewhat artificial one, and the interrelationships of the principal classes and orders are by no means completely understood.

The life-cycle of all embryophytes shows two marked phases, sexual and non-sexual. This "alternation of generations" is most conspicuous in the lower members, the mosses and ferns. The sexual plant (gametophyte) bears the sexual organs, archegonium and antheridium, which contain the sex cells (gametes), the eggs and sperms. The archegonium in the liverworts and mosses is a flask-shaped structure, the neck consisting of usually 5 to 6 outer rows of cells, and an axial row whose lowest cell is the egg which occupies the base or "venter" of the archegonium.

The antheridium is less uniform than the archegonium. It may be a capsule, having a single layer of wall cells, enclosing a mass of "spermatocytes," each containing a bi-ciliate spermatozoid. The least specialized types are found in the lower pteridophytes. The greater part of the spermatozoid is composed of the nucleus of the spermatocyte.

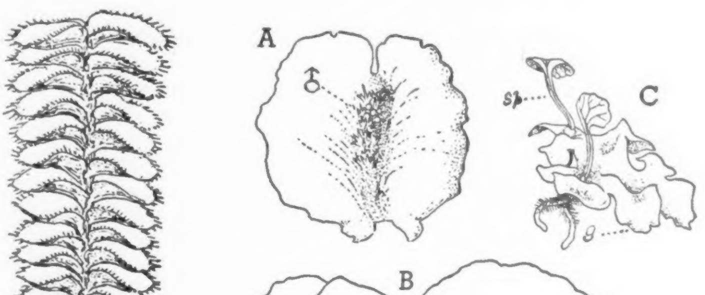
That the embryophytes are descended from aquatic ancestors is generally admitted. Of the Algae, certain fresh-water green algae most nearly resemble the lower embryophytes.

How and when the algal ancestors of the embryophytes took to the land is of course purely conjectural. The change from the aquatic habitat to life on land was presumably a very gradual one. There are still some very simple green algae which are adapted to terrestrial life, such as the unicellular *Protococcus* which vegetates so long as the atmosphere is sufficiently moist, becoming dormant when moisture is lacking. More striking is the curious little alga *Botrydium*, which grows on damp soil and is provided with a relatively extensive root system which enables it to absorb water for a relatively long time.

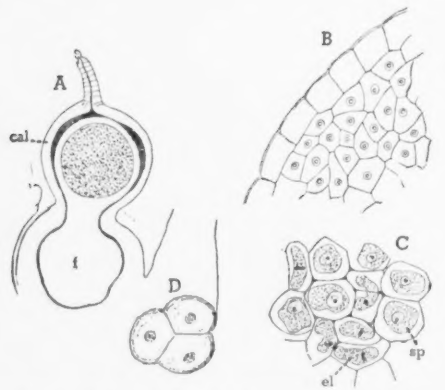


A, Unicellular Terrestrial Alga *Protococcus;* B, botrydium, a terrestrial alga showing branched roots, r; C, an amphibious liverwort, *Riccia natans;* sp. sporophytes.

The translation to land involves a complete readjustment of the plant to its water relation. The exposed surfaces must be protected against excessive evaporation, and this of course implies a diminution of power to absorb water from outside, and water is obtained, mainly, through a root system. The need for rapid distribution of water through the plant is met by the development of an elaborate "fibro-vascular" system of conducting tissues in the higher plants.

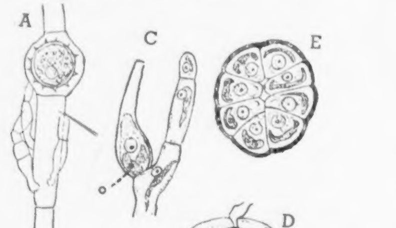


A, Thallose Gametophyte of a Liverwort, *Calycularia.* B, gametophyte of a fern *Gleichenia,* ventral view showing antheridia ♂, archegonia, ♀, r. rhizoids; C, gametophyte, g. of a fern, *Danæa,* bearing two young sporophytes; D, gametophyte of a leafy liverwort, *Plagiochila.*



A, Young Sporophyte of a Liverwort, *Targionia*, enclosed in the calyptra, cal., and the foot, B, section of the capsule, showing the young sporogenous tissue; C, an older stage, showing segregation of the spore-mother-cells and the elaters; D, young spore tetrad of *Fossombronia*.

The uniform conditions of the environment have tended to great conservatism in many fresh-water organisms, like some of the simpler green algae and protozoa which probably have come down little altered from the remotest antiquity. Once established on land, however, the environment is immensely more varied and the scope for the evolution of new forms correspondingly increased.



A, Oögonium of a Green Alga, *Œdogonium*, containing a ripe resting spore (zygote); B, archegonium of *Riccia* containing the multicellular embryo; C, oögonium of *Coleochaete*, o. the egg; D, ripe zygote of *Coleochaete* showing great increase in size; E, germinating zygote. (C–E after Oltmanns.)

The gametophyte may be of relatively large size in some of the liverworts and mosses; but in some of the pteridophytes and flowering plants it becomes greatly reduced in size, and finally in the flowering plants is of microscopic dimensions and generally overlooked.

The ciliated spermatozoids resemble those of some of the green algae and like them need free water in order to function. When wet, the antheridium discharges the spermatozoids which swim to the archegonium, which opens and permits their entrance. The necessity of free water for effecting fertilization indicates that the gametophyte has developed from some aquatic algal ancestors. The fertilized egg is called the "zygote." In the green algae the zygote usually develops a thick wall and becomes a "resting spore," which survives periods of drought, and may be said to be the terrestrial phase of the plant. When it germinates, it produces free swimming spores, from which the new generation arises.

The spermatozoid penetrates the egg-cell and the chromosomes of the two gametes are mingled in the nucleus of the "zygote" formed from this union, which has thus twice the number of chromosomes of the "haploid" nuclei of the gametophyte and is "diploid." The fertilized egg (zygote) increases in size and undergoes repeated divisions and forms the multicellular "embryo," all of whose cells have diploid nuclei.

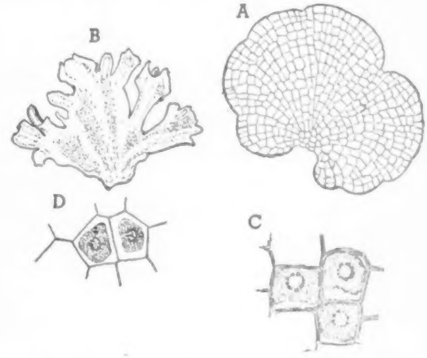
The embryo finally develops into the more or less complex structure, the "sporophyte," which sooner or later produces certain cells which divide into tetrads of "spores." The first division in the spore mother-cell is a "reduction division" or "meiosis," and the spores have the haploid chromosome number. Spore formation is a non-sexual process and the sporophyte is strictly an asexual or neutral organism. The spores on germination produce the haploid gametophytes.

Assuming the embryophytes have been derived from some algal ancestors, and that the sporophyte is an elaboration of the unicellular zygote, or resting spore of an alga resulting from the union of the gametes, we may say that the sporophyte of the embryophytes, like the algal zygote, represents the terrestrial phase of the organism contrasted with the aquatic or amphibious gametophyte. As the terrestrial habit becomes more pronounced the sporophyte assumes increasing importance until finally it becomes the dominant phase in the life-cycle.

The gametophyte reaches its highest degree of specialization in some of the large true mosses. These develop relatively large leafy shoots, which show special mechanical and conducting tissues, which might be compared to those in the fern-sporophyte. The roots, however, never reach the complex structure found in the ferns and seed-plants, and the mosses depend only to a limited extent upon their hair-like roots for their water supply, but absorb water directly through the leaves, thus behaving like algae.

The apparent inability of the gametophyte to develop adequate roots probably accounts for its failure to reach dimensions at all comparable with the sporophytes of many of the higher plants. So far as known the higher mosses represent the extreme development on land of these originally aquatic organisms, which seem unable to produce a plant type perfectly adapted to life on the land.

The further evolution of the plant kingdom is concerned mainly with the neutral generation — the sporophyte. This may be traced back to the "zygote" or resting spore, developed in many green algae, as the last phase in their life-history. The zygote may be said to represent the terrestrial phase of the alga, as it is fitted to survive drought,

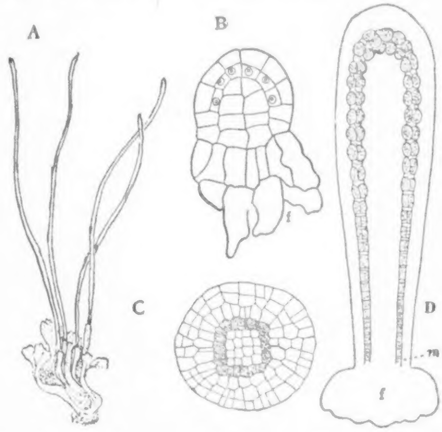


A, *Coleochaete scutata* a green alga; B, gametophyte of *Notothylas* (anthocerotaceæ); C, chromatophores of *Coleochaete;* D, chromatophores of *Megaceros* (anthocerotaceæ).

and carry the plant over from one growing period to another.

The sporophyte is, therefore essentially a terrestrial organism.

While there is a wide gap between the zygote of any known alga and the simplest sporophyte among the liverworts, nevertheless a comparison of the two may help to explain the origin of the sporophyte in the archegoniates.



A, Gametophyte of Anthoceros bearing four sporophytes; B, embryo of *Anthoceros,* longitudinal section, the nuclei are shown in the cells of the primary sporogenous tissue, the archesporium; C, cross section of an older embryo, the archesporium shaded; D, diagram showing the development of the sporogenous tissue from the basal meristem, m; f. the foot.

In the green alga, *Coleochaete,* there is a marked increase in size of the zygote after fertilization, and the formation of a globular cell-mass on germination, which suggests the early divisions in the simplest known sporophyte of the embryophytes — that of the liverwort, *Riccia,* where the fertilized ovum forms a globular mass of cells, the embryo, all of whose cells, except the single superficial layer, are spore mother cells. It is probable that in the first embryophytes all the cells are sporogenous.

The further evolution of the sporophyte is associated with an increasing subordination of the sporogenous or "fertile" tissue to sterile vegetative tissues. This "sterilization" of potentially sporogenous cells, as the most important factor in the evolution of the sporophyte, has been especially emphasized by Professor F. O. Bower. The theory of progressive sterilization explains the increasing importance of the sporophyte in the history of the land plants.

In most of the liverworts (Hepaticae) there is an early division of the embryo into an upper (epibasal) sporogenous region and a lower (hypobasal) sterile region. The latter develops a "foot" or haustorium, through which the embryo receives nourishment from the gametophyte, upon which the young sporophyte is thus parasitic. The epibasal region develops a capsule, whose inner tissue is composed, at least in part, of potentially sporogenous cells. Some of these become spore mother cells and produce the characteristic spore tetrads.

In the Hepaticae the sporophyte, except in its early stages, has little green tissue, and must, therefore, depend largely upon the gametophyte for its food supply, the whole development of the sporophyte (sporogonium) being mainly devoted to the production and dispersal of the spores. After the spores are shed there is a complete collapse of the sporogonium.

In the other classes of the bryophytes the mosses (Musci) and the Anthocerotes, there is a marked reduction in the sporogenous tissue, and the development of a considerable amount of green tissue which permits photosynthesis, and thereby enables the sporophyte to manufacture part, at least, of its necessary food; and except for its water supply, renders the sporophyte, to some extent, independent of the gametophyte.

The first group of embryophytes—the bryophytes includes three classes, Anthocerotes, Hepaticae (liverworts) and true mosses (Musci). So far as known, these all agree in having minute bi-ciliate spermatozoids, resembling those of some green algae (Chlorophyceae). The order Ulothricales, both in cell structure, and to some extent in reproduction, approaches most nearly to the lower embryophytes. The gametophyte of the latter may be a quite undifferentiated flat thallus, composed of uniform cells, each with a single chromatophore, very much like that of the Ulothricales. In all the bryophytes and pteridophytes there is a definite archegonium developed, and these two groups are often called the Archegoniates.

The relationships of the three classes of the bryophytes are by no means clear. The Anthocerotes are very generally placed with the Hepaticae—but they differ so markedly from the other bryophytes as to warrant their separation as a distinct class.

The Anthocerotes form a very natural class, with no very evident relationship with the other bryophytes. While the gametophyte is perhaps the most primitive among the Archegoniates, the sporophyte is much better developed than in any of the Hepaticae.

In the genus *Anthoceros,* the conditions approach those of the simplest vascular plants.[1] At an early period there is formed between the foot and the

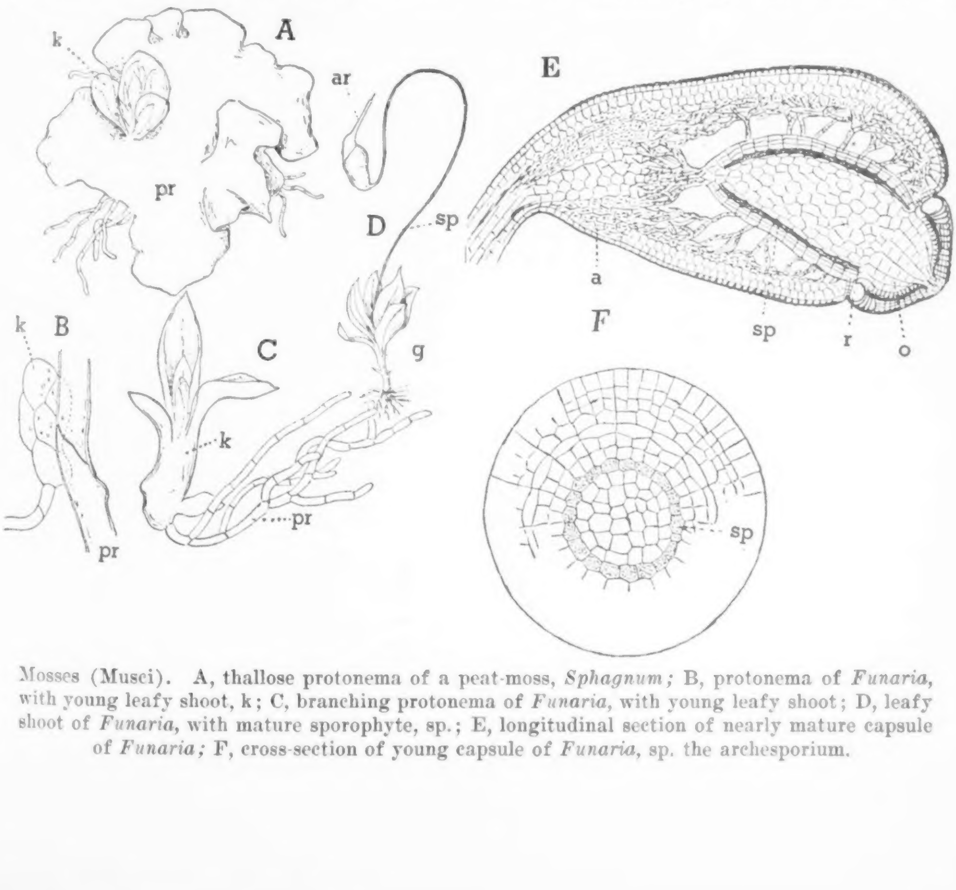
[1] Pteridophytes, Spermatophytes.

sporogenous region of the embryo a zone of rapidly growing cells (meristem), which may retain its activity for several months, and the apical region is thus pushed up and rapid elongation results, the sporophyte sometimes reaching a length of 10 centimeters or more. The sporogenous tissue (archesporium) consists of a single layer of cells enclosing an axial cylinder, the "columella," which sometimes, at least, seems to be an efficient conductor of water, absorbed by the large foot. Outside the sporogenous layer are several layers of green cells, and an epidermis with stomata like those of the higher plants. There is thus an efficient photosynthetic apparatus, and the structure of the sporophyte suggests that of the simplest so-called vascular plants.

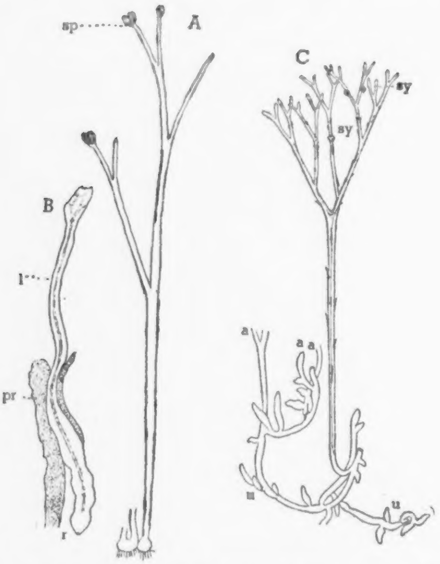
In the Hepaticae, the gametophyte may be an undifferentiated thallus comparable to that of *Anthoceros* but there is a considerable range of structure within the class. Thus in the genus *Pallavicinia*, as well as some others, the gametophyte has a distinct midrib which may have a central strand of conducting cells—suggesting the fibro-vascular bundles of the higher plants. In other genera there is the development of marginal lobes which may assume a definite leaf-like form. These "leaves" have evidently been developed independently in several unrelated families.

In other cases, the thallose form of the lower liverworts is retained but there is a notable differentiation of the tissues. In these there is a very definite epidermis and a system of air chambers containing chlorophyllous cells and communicating with the exterior by means of special pores in the epidermis.

In the true mosses (Musci) the gametophyte in most cases consists of a system of branching alga-like filaments, the



Mosses (Musci). A, thallose protonema of a peat-moss, *Sphagnum;* B, protonema of *Funaria,* with young leafy shoot, k; C, branching protonema of *Funaria,* with young leafy shoot; D, leafy shoot of *Funaria,* with mature sporophyte, sp.; E, longitudinal section of nearly mature capsule of *Funaria;* F, cross-section of young capsule of *Funaria,* sp. the archesporium.



A, *Hornea*, one of the earliest known vascular plants, restoration by Kidston and Lang; sp. sporangia; B, *Ophioglossum*, a primitive fern, section of young sporophyte showing only the first leaf, and primary root pr. gametophyte; C, *Psilotum*, probably the nearest living relative of the fossil *Homea*.

"protonema," from which the leafy shoots arise. These leafy shoots may reach considerable size, and the stem may have a well-developed conducting strand comparable with the vascular bundles of the higher plants. The leaves also are sometimes relatively large, and generally have a conspicuous midrib. These large mosses represent the most perfect development achieved by the gametophyte of the embryophytes.

If we regard the gametophyte of *Anthoceros* as the most primitive among the embryophytes, it may be that the other bryophytes, the Hepaticae and Musci, perhaps represent two divergent lines arising from some *Anthoceros*-like common stock.

PTERIDOPHYTES

In the pteridophytes the sporophyte becomes an independent plant, developing definite organs, leaves, roots and special spore-producing organs, sporangia. At an early period, in most cases, the primary root ruptures the gametophyte and penetrates the substratum and the plant thus becomes entirely independent. The sporophyte may ultimately attain a large size and live for many years.

The history of the sporangial structures shown by the fossil record as well as by the comparative anatomy of the more primitive living types makes it pretty clear that the sporangia are not primarily modifications of stem and leaf structures, but are primary organs. While in many of the more specialized ferns the sporangia arise from superficial cells of the leaf, in the more primitive types before the plant body was differentiated into stem and leaves, definite sporangia are present, and the sporangium must be considered as a primary organ of the sporophyte and not as a secondary one. The sporangia are often borne on special structures, sporangiophores.

The pteridophytes and spermatophytes always have a very definite system of conducting tissue, the "fibro-vascular" bundles, hence they are often called the "vascular" plants.

The simplest known vascular plants are two fossil genera, *Rhynia* and *Hornea*, first described by Kidston and Lang[2] from the Lower Devonian of Scotland. They were slender leafless plants sometimes scarcely exceeding in size the sporophytes of some species of *Anthoceros*. Some of the branches bore simple sporangia which show some resemblance to the spore arrangement in the *Anthocerotes*.

The section of the shoot also resembles a similar section of certain large sporophytes of *Anthoceros;* and so marked are the resemblances between these ancient pteridophytes and the sporophyte of *Anthoceros* that it seems possible the

[2] R. Kidston and W. H. Lang, *Trans. Roy. Soc. Edinb.*, 1–5, 1917–1921.

Rhyniaceae were derived either from some of the *Anthocerotes* or from forms resembling them.

Perhaps related to the Rhyniaceae are several more highly specialized Devonian types which it has been suggested might be the prototypes of the living pteridophytes. Of the latter the ferns (Filicineae) are characterized by the marked development of the leaves; in the horse-tails (Equisetaceae) and the club-mosses (Lycopodiaceae) the axis is predominant and the leaves relatively secondary.

Classification of Pteridophytes

The existing pteridophytes include four classes,—1. Psilotineae; 2. Filicineae (ferns); 3. Equisetineae (horse-tails); 4. Lycopodineae (club-mosses).

The Psilotineae are few in number, with only two genera, *Psilotum* and *Tmesipteris;* and are the nearest living relations of the Devonian Rhyniaceae. The commonest species is *Psilotum triquetrum,* occurring in tropical and subtropical regions of both hemispheres. It has a much-branched subterranean rhizome, from which upright dichotomously branched shoots arise. There are only rudimentary scale leaves and no roots, and there is a distinct superficial resemblance to *Rhynia.*

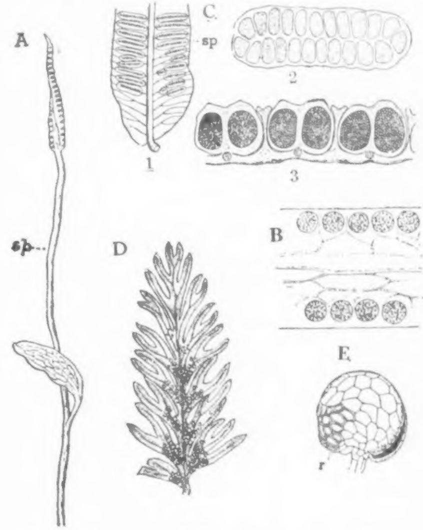
The spores in the Psilotaceae are formed on a short branch, or sporangiophore, and are in two (*Tmesipteris*) or three (*Psilotum*) separate masses forming a "synangium" instead of the individual sporangia found in most of the pteridophytes.

The gametophyte is a subterranean body, without chlorophyll. The spermatozoides are multiciliate.

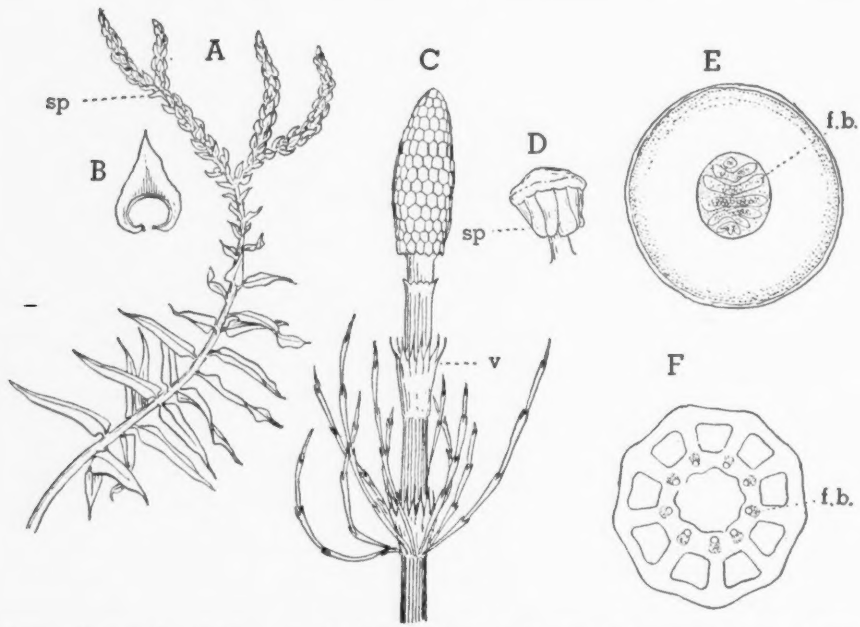
The three other classes can be traced back to the Palaeozoic, where many fossil forms occur. Whether these three classes have arisen from a common Devonian stock related to the Psilophyta is not clear, but fossils evidently related to all the existing classes occur in early Carboniferous rocks and probably in the Devonian.

At the present time the ferns greatly outnumber all the other pteridophytes and constitute the great majority of existing species.

The great majority of ferns belong to the section Leptosporangiatae, evidently a comparatively modern group. In these the sporangium is often developed from a single epidermal cell. The ferns are characterized by the predominance of the leaves, which in some of the tree-ferns reach a size and complexity which is rivaled by few of the higher plants. The more primitive ferns, the Eusporangiatae, have much larger and less specialized sporangia than those of the Leptosporangiatae. The Eusporangiatae are best developed in the tropical and subtropical regions. There are two orders, Ophioglossales and Marattiales, each



A, Ophioglossum *Moluccanum,* sp. the conspicuous sporangiophore; B, section of the sporangiophore of *O. pendulum,* showing the separate masses of spores; C, (1) lower surface of a leaflet of *Danæa,* showing the elongated synangia, (2) horizontal section of a synangium, (3) transverse section of three synangia; D, leaflet of *Leptopteris,* showing scattered free sporangia; E, a single sporangium of *Leptopteris;* r, annulus.



A, *Lycopodium pachystachyon.* B, single sporophyll; C, *Equisetum limosum;* v. leaf sheath; D, sporangiophore, and sporangia of *Equisetum;* E, section of stem of *Lycopodium dendroideum;* F, section of stem or *Equisetum arvense.* F.b.—fibro-vascular bundles.

with a single family. In the Ophioglossaceae the sporangia are borne on a large sporangiophore, which sometimes, at least, is formed by a forking of the very young leaf into a fertile sporangiophore and sterile lamina. In *Ophioglossum* the sporangiophore is a flattened spike, the sporangia forming a single row on each margin. Each sporangium consists of a large mass of sporogenous tissue, opening by a cleft on the surface of the sporangiophore.

The Marattiales have the sporangia borne on the lower surface of the leaves, as in the common ferns, but in most cases the sporangia are not free but are united into a "synangium."

The gametophyte of the ferns usually resembles that of the more primitive Hepaticae. In the Marattiaceae the large fleshy thallus might readily be mistaken for a liverwort.

In most of the ferns the sporangia are all alike and the spores produce gametophytes which often bear both antheridia and archegonia. There are, however, a few ferns, the Hydropterides or water ferns, in which two types of sporangia are produced. These are of different size, the larger megasporangium, having a single very large spore, the megaspore, from which the female gametophyte is developed. The smaller microsporangia produce many "microspores" which give rise to the greatly reduced male gametophytes.[3] Heterospory has developed in several quite unrelated families.

The Embryo

In the lower ferns, the first division of the embryo is transverse and the basal walls separate a lower foot region from the upper region from which the leaf

[3] The development of these two types of spores is known as "heterospory," and this has arisen in several unrelated groups of pteridophytes. Where all the spores are alike the plants are "homosporous."

and stem develop. The young embryo, therefore, may be described as bipolar. The embryo at this stage may be compared with that of *Anthoceros.* The embryo may reach a considerable size before the organs of the young sporophyte are recognizable and perhaps those forms in which early differentiation occurs are the more recent and specialized.

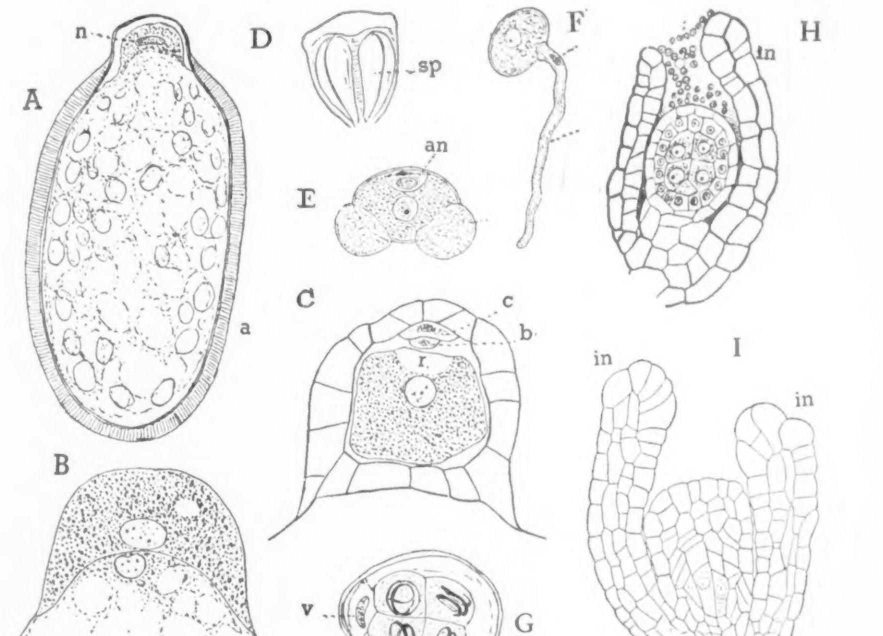
The leaf soon assumes the leading role in the development of the young sporophyte and the stem may be completely suppressed in the young stages of some species of *Ophioglossum,* a genus which for several reasons may be regarded as the most primitive of existing ferns.

Equisetineae

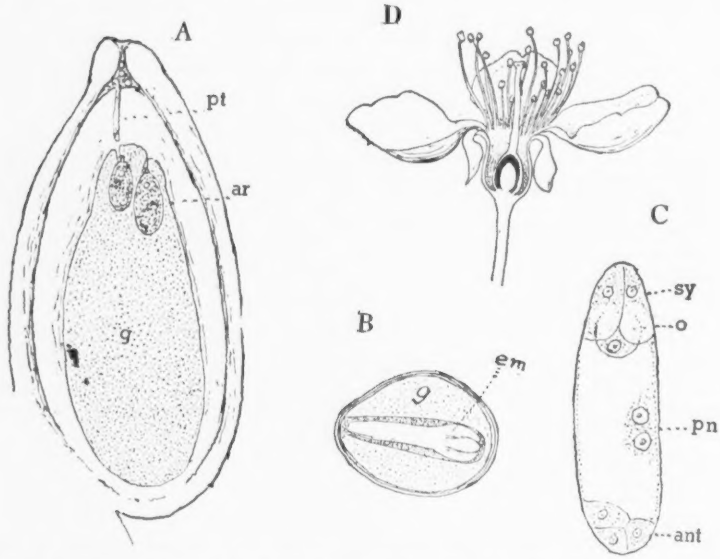
The Equisetineae have only a single living genus, *Equisetum.* The hollow-jointed stem and rudimentary leaves show little resemblance to any of the ferns, but the large green gametophyte is not very different and the sex organs are similar. The large multiciliate spermatozoids closely resemble those of the lower ferns and the embryos have some points in common. Some of the fossil Equisetineae had functional leaves, and it is possible that a real, if very remote, relationship may exist between the Equisetineae and Filicineae.

Lycopodineae (Club Mosses)

The Lycopodineae have little in common with the other pteridophytes and probably had an entirely separate origin. They include both homosporous and heterosporous forms. The gametophytes



Heterospory. A, section of megaspore of *Marsilea;* n, nucleus. B. C, development of the female gametophyte and archegonium of *Marsilea;* D, scale from the staminate cone of a pine, showing two microsporangia (pollen-sacs); E, pollen-spore of a pine, the enclosed male gametophyte shows the antheridial cell, An.; F, germinating pollen-spore of sweetpea; G, microspore of *Isoetes,* enclosing the male gametophyte, v. prothallial cell, four spermatozoids; H, megasporangium of a water-fern, *Azolla;* I, young megasporangium (ovule) of redwood (*Sequoia*).



Seed Plants. A, mature ovule of a pine, showing the large female gametophyte, g. with two archegonia; a pollen-tube, pt, is penetrating the ovule; B, section of pine seed, g. the gametophyte (endosperm), em. the embryo; C, embryo sac of an angiosperm; at the apex the egg apparatus; o, the egg, sy. synergids; at base, three antipodals; p.n. polar nuclei; D, section of a cherry flower, an angiosperm showing the various organs.

of the homosporous forms (Lycopodiaceae) are mostly subterranean and destitute of chlorophyll, although some develop chlorophyll. The sexual organs, especially the archegonia, recall the mosses.

The leaves are small with a simple midrib, the whole sporophyte with the slender stem and numerous leaves suggesting some of the larger mosses, hence the common name, "club mosses." There are many fossil lycopods, some of them being trees, like the living conifers. Some of the fossils, however, are closely related to the living genera, *Lycopodium* and *Selaginella*. In some of the larger fossil forms, *e.g.*, *Lepidodendron*, seeds were formed.

Heterospory and the Seed Habit

The occurrence of heterospory in several unrelated pteridophytes must be borne in mind in considering the origin of seeds, in both living and extinct plants. In the water ferns, Hydropterides, the ripe megaspore is unicellular and contains reserve food materials from which the developing gametophyte is nourished. In *Selaginella*, of the Lycopodineae, the development of the gametophyte begins long before the megaspore is full grown and it reaches its full development while the megaspore is still retained in the sporangium. The conditions are very much like those in the lower seed plants, the so-called "gymnosperms." In the seed plants the megasporangium is known as the "nucellus" of the ovule, or young seed. Thus the development of the gametophyte within the megaspore (embryo-sac), in a pine, for example, is very much like that in *Selaginella*.

The microspores (pollen-spores) of the seed plants differ but little from those of the pteridophytes. The megaspore with the contained gametophyte remains within the ovule and the archegonium is fertilized by means of the male gametes formed in the rudimentary

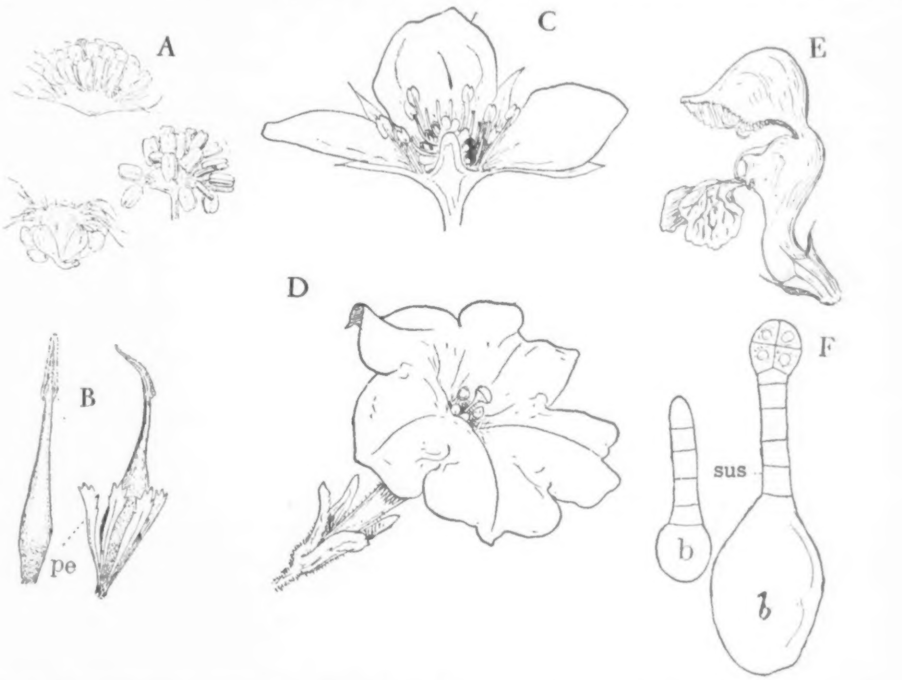
male gametophyte developed from the pollen-spore which is deposited on the apex of the ovule. The pollen-spore germinates and forms a tube which penetrates the apex of the nucellus and reaches the archegonium. With few exceptions the male gametes are not ciliated and free water is no longer essential for fertilization of the egg. After fertilization the outer tissues of the ovule become hard, forming the seed-coat, and the cells of the gametophyte, in which the embryo is embedded, are filled with reserve food. This gametophytic tissue is the "endosperm" of the ripe seed.

That like heterospory seeds have developed independently in several phyla is shown clearly by a study of the Palaeozoic floras. While some of the ancient seed plants show a relationship with existing types others are apparently quite unrelated to any living plants.

Among the most abundant of the Palaeozoic seed plants were the "Pteridosperms," usually with fern-like foliage, but bearing simple seeds. The oldest pteridosperms are found in the late Devonian. Other Palaeozoic seed plants were related to the Lycopods. No examples are known of seed formation in the Equisetineae.

Since it is clear that the seed habit has originated independently in various groups of pteridophytes, it is practically certain that the living seed plants are not all descended from a single primitive stock.

The primitive seed plants are "gymnosperms," *i.e.*, the ovules are not borne in a closed ovary. They show evident derivation from pteridophytic ancestors,



Types of Angiospermous Flowers. A, staminate flowers of poplar; B, pistillate flowers of *Sparganium simplex;* C, apocarpous flower of strawberry; D, (radial) actinomorphic sympetalous flower of *Petunia;* E, (bilateral) zygomorphic sympetalous flower of dead-nettle (*Lamium*); F, young embryos of shepherd's purse; sus. suspensor.

although not certainly related among themselves. The ancestry of the predominant flowering plants, the angiosperms, is very obscure, and is still the subject of much controversy.

The existing gymnosperms include four orders, Cycadales, Ginkgoales, Coniferales and Gnetales. The first two are very natural groups, but the others show much greater diversity, and their interrelationships are not very clear. The Cycadales and Ginkgoales show pretty clearly that they are related to the ferns. In one respect they differ from all the other living seed plants. The male gametes are large multiciliate sperms, recalling those of the lower ferns.

The cycads include about 85 living species which have fern-like leaves and resemble in many respects the structures of the eusporangiate ferns.

The Ginkgoales are represented by a single living species, *Ginkgo biloba*, sometimes cultivated in America. The leaves resemble in their venation the leaflets of some ferns. *Ginkgo* is not known in a wild state, but fossil remains of Ginkgoales are wide-spread from the early Mesozoic onward and are very much like the living species.

Abundant remains of foliage and stems of cycadean type are found from the late Palaeozoic through the Mesozoic. Many of these have been found to belong to another order of cycadophytes—Bennettitales—now quite extinct. They had much more specialized flowers than the true cycads, and it has been thought by some botanists that the Bennettitales were the ancestors of the flowering plants, but this is very doubtful.

Coniferales

The existing cycads and *Ginkgo* are evidently relicts of a flora once much more extensive than at present. The Coniferales, although comprising only about four hundred living species, play a very important role in the vegetation of the modern world. Over extensive areas, like western North America and parts of Europe and Asia, they form the major elements in the forests. They are sometimes trees of gigantic size, like the redwoods, pines and firs of the Pacific Coast.

Gnetales

The order Gnetales has three genera which differ very much in appearance and are evidently not closely related. Only one genus, *Ephedra*, occurs in the United States. The other genera are mostly tropical.

From the Permian through the Mesozoic, gymnosperms were predominant. From the Lower Cretaceous onward they diminish in importance and are superseded by the angiosperms, Anthophyta ("flowering plants"), which at present form an overwhelming proportion of the vegetation everywhere. The angiosperms differ greatly from the gymnosperms in their adaptability to all conditions where plant-life is possible. They range from almost microscopic aquatics to giant trees, rivalling the largest conifers. At least 150,000 species of angiosperms have been described, while the total number of species of living gymnosperms is probably not more than 500.

In the angiosperms the ovules (young seeds) are borne in a special closed structure, the ovary, instead of being exposed like the ovules of the gymnosperms.

The flowers of the angiosperms show an extraordinary range of structure. The essential organs are the stamens and carpels, which are usually in the same flower, but may be separated. The stamen which might be regarded as a sporangiophore usually has a stalk (filament) bearing in most cases a synangium (anther) with four microsporangia (pollen-sacs). The development of the

anther is very much like that of the synangium of some of the lower ferns. The ovules (megasporangia) are borne at the base of the carpels, which may be separate or united into a "pistil." The base of the pistil is the ovary, above which is the cylindrical "style," bearing at its summit the stigma, upon which the pollen spores are deposited. The carpels are commonly considered to be "sporophylls," *i.e.*, modified leaves, but the foliar nature of the carpels is at least questionable.

In its simplest form the flower may consist of a single stamen or carpel, but more commonly both organs are present and in addition there is a more or less conspicuous envelope or perianth, with two series of leaf-like members, sepals and petals, forming the "calyx" and "corolla." The sepals are generally green and leaf-like, but the petals are usually delicate in texture and often showy. They probably represent modified stamens.

Many of the specialized characters found among the angiospermous flowers are obviously associated with pollination by insects, which have played a very important role in the evolution of the flowers; and there are very many examples of mutual adaptations between insects and flowers.

The geological history of the angiosperms is very incomplete. There is abundant evidence of the existence of certain living genera, *e.g.*, *Sassafras*, *Platanus*, in the Lower Cretaceous, and this implies a long line of more primitive types presumably extending into the Jurassic, but as yet the evidence is very uncertain.

The distinguished botanist, Engler, in the introduction to the angiosperms in the "Natürliche Pflanzenfamilien," assumes the existence, probably in the Jurassic, of an extensive and wide-spread assemblage of "Protangiosperms," from which many independent lines of true angiosperms arose. However, as yet none of these protangiosperms have been definitely recognized.

In the absence of satisfactory fossil data, the problem of the origin of the angiosperms must, for the present, remain largely conjectural. It seems unlikely that they are directly related to any of the existing gymnospermous orders, and it has been suggested that they may have originated directly from some type related to the ferns, or possibly the pteridosperms.

MERIDA, VENEZUELA—FROM ISOLATION TO INTEGRATION[1]

By Dr. RAYMOND E. CRIST
DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF ILLINOIS

Swiftly moves the wind; swiftly moves the stream; swiftly moves the rock that falls from the mountain.
Run, warriors, run out against the enemy, run swiftly, like the wind, like the stream, like the rock that falls from the mountain.
Strong is the tree that resists the wind; strong is the rock that resists the river; strong is the mountain snow that resists the sun.
Fight, warriors, fight valiantly, show yourselves strong—like the trees, like the rocks, like the snows of our mountains.

—*War chant of the Indians of the Venezuelan Andes*

The native Venezuelan poet made use of the imposing phenomena of the high mountains to symbolize the impetuous attack: the howling wind which, in the high passes, can even blow over horse and rider; the mountain torrent which sweeps all before it; the massive rock which breaks loose from a peak and flattens everything in its path. In the great tree that calmly resists the wind; in the huge rock that even the rushing stream can not dislodge; in the perpetual snows of the peaks which resist the tropical sun—in these phenomena the bard visualizes the defensive strength of those who fight for their native land.

In the short distance between the mountains of Mucuchíes, which inspired this American Homer, and Lagunillas del Urao—some fifty miles—almost any of the plants known in the world will thrive. It is not unusual for one hacendado to have within the limits of his hacienda fields of cacao and sugar-cane in the irrigated area along a river and patches of wheat and potatoes high up in the cold country. This short altitudinal traverse would represent a difference in latitude of a thousand miles or more—from the sugar-cane plantations of southern Louisiana to the wheat and potato fields of the valley of the Red River of the North.

One of the most characteristic geologic and topographic features of the Venezuelan Andes are the extensive terraces, the remains of vast alluvial flats which, during the Ice Age, were deposited by the overloaded streams coming from the melting glaciers, then much more extensive than now. The underloaded rivers of the post-glacial epoch, in cutting their beds to new base-levels, have eroded deep V-shaped valleys into the older alluvium, leaving extensive terraces or mesas high above their present level.

In the first days of June of 1558 Captain Juan Rodriguez Suarez set out northeastward from Pamplona with 100 men, in the search for new mines. He passed the sites where Cúcuta, San Cristóbal, La Grita and Bailadores are now located, and had many encounters with the Indians. At last he descended to the valley of the Chama at Estanques, and continued on up the arid valley past Lagunillas del Urao, where he found a dense population of peace-loving, industrious Indians. From Lagunillas eastward the country rapidly loses its desert aspect; streams become abundant, hills are wooded. The traveler is reminded now of New England, now of Brittany, now of the high Alpine meadows, depending on the time of year, the time of day or upon one's mood. At last, on October 9, 1558, Suarez reached the present site of Ejido, on a "high mesa, clean, with clear water, a beautiful view of the Sierra Nevada, and a temperate climate."[2] Where the Milla, Albarregas

[1] The work on this article was made possible by grants from the Guggenheim Foundation and the Graduate Research Board of the University of Illinois.

[2] Fray Pedro Simon, "Noticias Historiales de las Conquistas de Terre Firme," p. 196. Bogotá, 1882.

VILLAGE OF LAGUNILLAS AND THE LAKE
FROM WHOSE WATERS "TRONA" IS EXTRACTED. THIS MINERAL IS MIXED WITH A TOBACCO EXTRACT TO FORM A BLACK PASTE CALLED "CHIMÓ," WIDELY USED BY THE ANDINOS.

DEEP V-SHAPED VALLEY CUT BY THE MUCUJUN RIVER
THE ALLUVIAL FLATS WERE DEPOSITED BY THE OVERLOADED STREAMS OF THE ICE AGE.

and Mucujun rivers join the turbulent Chama, an especially well-developed and extensive alluvial flat has been incised by the rejuvenated streams, forming a vast mesa of rich older alluvium, which must have seemed a veritable Garden of Eden to the dusty, sunburned captain and his men. He immediately assigned parcels of land to his soldiers and named the city "Mérida," after Merida, in Extremadura, Spain, his native city.

The three classes of towns in Latin America, according to origin, are: I. Towns of Indians, located either where they were found by the Conquistadores, or on a site designated by them. Spaniards were not allowed to live in these towns, and the Indians governed themselves under the supervision of the colonial authorities. To these towns or communities the king granted certain lands called "Resguardos de Indígenas," which lands were worked communally until, under the Republic, they were surveyed and divided among the Indians. II. Those which, without official founding, from an agglomeration of houses (hamlet), grew into villages or even, if the positions were favorable, into full-fledged towns or cities. Generally towns of this kind developed on sites owned by private individuals, or on land donated for such a purpose by some rich benefactor. III. Those towns which were directly founded by Spaniards, as a Villa (town) or Ciudad (city). Many formalities had to be complied with for such a foundation, beginning with permission of the King, the Real Audiencia or the Governor of the Audiencia. The act of founding was carried out with much pomp, and one of the first acts after the imposing ceremony was the designation of the sites for the public plaza, the church and the town hall. The "Ejidos," or common lands, of the new town were laid out at the same time.

A PRIMITIVE "TRAPICHE" OR SUGAR MILL IN OPERATION
THE MOTIVE POWER IS SUPPLIED BY A YOUNG OX.

But to return to Captain Suarez. On October 14, 1558, he wrote a letter to the Cabildo of Pamplona in which he told of assigning lots to his soldiers in the new town, spoke of the lovely view of the

PANORAMA OF ALLUVIAL TERRACES DOWNSTREAM FROM EJIDO

DISSECTED IN THE FORM OF FLAT-IRONS. ON BOTH THE OLDER ALLUVIAL FLAT AT THE HIGH LEVEL AND THE MORE RECENT ALLUVIAL TERRACE BELOW ARE IRRIGATED FIELDS OF SUGAR-CANE.

VERTICAL CLIFF OF OLDER ALLUVIUM AS SEEN FROM A CANE FIELD

A PILE OF "BAGASSE" DRYING IN THE SUN

THE BAGASSE, WHEN DRY, IS USED AS FUEL TO BOIL THE CANE JUICE TO A THICK SYRUP. THE SYRUP, WHICH LOOKS LIKE TAFFY CANDY, IS COOLED IN A HUGE WOODEN VAT AND POURED INTO MOLDS, WHERE IT HARDENS AND FORMS YELLOW SUGAR, "PANELA" OR "PAPELON," USED LOCALLY.

THE MOUNTAIN VILLAGE OF SAN RAFAEL, NEAR MUCUCHIES

FROM WHICH MANY PEASANTS MUST EMIGRATE. THE STEEP SLOPES AND ROCKY SOIL ARE NOT PRODUCTIVE, AND THE POPULATION INCREASE IS GREATER THAN INCREASE IN FOOD PRODUCTION.

Sierra Nevada, and mentioned the great number of people. He wrote that there were as many buildings as in Rome (straw huts, to be sure, as Fray Simon says), that he had found the best esteras (sleeping mats) that he had seen in the kingdom, and he requested that thirty or forty more soldiers be sent him, as they would be necessary in the pacification of so many people.

When Captain Juan Maldonado, son-in-law of Ortún Velasco, governor of Pamplona, heard of Suarez's activities, he became jealous and had the governor issue a warrant for his arrest, alleging actions outside his authority—particularly the founding of a town and the granting of land—and cruelties to the Indians. Maldonado then had himself appointed Governor of Mérida, which he moved from its former site, where Ejido now stands, to its present site, more as a protest against Suarez than for any other reason. After this he began explorations to the east, crossed the paramo to subdue the Timotes Indians, and finally reached the Boconó River. Here he met Captain Francisco Ruiz, who had been sent out to conquer these same provinces by the Gobernación of Venezuela. Thereupon he returned to Mérida and to the task of subduing the Indians.

The Caquetia and Jirajara Indians formed the dominant population around Mérida at the time of the conquest. They probably came originally from the Andes of Pasto, although it is hard to say why or when they left their native haunts to settle the Llanos and Andes of Venezuela. Perhaps the violent eruptions of the volcanoes of Pasto forced the people to seek new homes elsewhere, or perhaps the natural increase in population of these vigorous mountaineers made migration a necessity. Both tribes had entered the Venezuelan Andes from the

VALLEY OF UPPER CHAMA RIVER IN THE WHEAT COUNTRY AT MUCUCHIES

IN LEFT FOREGROUND THREE YOKES OF OXEN ARE BEING USED IN PLOUGHING A WHEAT FIELD WHICH IS BOUNDED ON TWO SIDES BY DEEPLY ERODED GULLIES. THE ALLUVIAL FAN ON THE OTHER SIDE OF THE RIVER IS INTENSIVELY CULTIVATED IN SMALL PLOTS FENCED IN BY STONE WALLS. THE CHAMA HAS BEEN PUSHED TO THIS SIDE OF THE VALLEY BY ALLUVIAL DEPOSITS OF ITS TRIBUTARY.

OXEN BEING UNHARNESSED FROM THEIR BURDENS AT THE KILN

south by the main river valleys, completely subjugating the highly developed sedentary population already there, which had probably immigrated originally from Central America. The words "mucu" and "moco," meaning place or site, is found all along the upper Santo Domingo River and from the mountains of Aricagua to the Sierra Nevada, eloquent evidence of the recent conquest by the invading Quechua—Guarami people. Similarly, the names "berg" and "land" are found widely distributed over areas conquered by Teutonic peoples.

The Indians resisted the Spaniards bravely; they dug trenches to impede their progress, and they built stone fences to ward off their attacks. But lack of food and water finally forced most of them to surrender. Many were killed, others fled to the high mountains, and not a few buried themselves alive in "mintoys," subterranean dugouts with a narrow entrance that the fugitives closed after them. Here they died, idols clasped in their arms. Those who retired to the mountains kept up guerilla warfare for a generation, but were finally subdued.

The common method of pacification was that of giving "encomiendas," grants of land together with the Indians living on them, to Spaniards who were to indoctrinate the natives with Christianity. During this process, which often lasted centuries instead of only two generations as specified in the grant, the Indians worked on the estates as serfs. When the owner died the estate and the serfs passed on to his son or son-in-law. If there was no legitimate heir the estate returned to the Crown, and the King could then give it to some other worthy subject. For example, when Captain Gonzalo de Valencia died, leaving his encomiendas of Lagunillas and the valley of Santo Domingo without an heir, Captain Juan Velasquez de Velasco had the governor of Mérida grant, with royal consent, these encomiendas to Juan Felix Jimeno de Bohorquez, who was about to become his son-in-law. The Velasco and Bohorquez families, with great

wealth in land and serfs, played a leading role in the affairs of Mérida for generations.

Undoubtedly the terrible living conditions of the fugitive Indians in the mountains, as well as of those who were working on the encomiendas of the conquerors, helped make the smallpox plague of 1588 especially virulent. It was estimated that at least one third of the total population died. This appreciable loss in the native labor force in turn played an important role in the introduction of Negro slaves, particularly for the sugar, indigo and tobacco haciendas of Barinas, which traded with Spain via Mérida and Lake Maracaibo. But as early as 1619 the cacao haciendas along the Chama were worked by gangs of Negro slaves.[3]

One of the first acts in founding a town was the assignment of Ejidos, or common lands, as perpetual property of the municipality. But many were the subterfuges whereby such commons finally became the private property of individuals who often paid little or nothing into the city treasury.

The Ejidos of Mérida, with an interesting history for over 350 years, were originally very extensive, including all the mesa to the southeast as far as the present town of Ejido—hence the name—and to the northeast beyond La Milla. A part of the Ejidos was subdivided in 1564, but in 1587 the Real Audiencia of Bogotá, at the instance of Captain Antonio de Reinoso, cancelled certain concessions made shortly before. In 1589 Pablo Garcia, Procurador of Mérida, insisted that the Ejidos to the southeast be subdivided, alleging that Captain Reinoso had a very personal reason for not wanting the parceling to continue, *viz.:* that he wanted to continue using that part of the Ejidos as free pastureland for his cows. "Between the creek of Pablo Garcia and the Chama River . . . is an area ten kilometers wide, every bit of it common land and quite deserted, and no one is making use of it except the person who has his cows there, and he doesn't worry too much about them."[4] Furthermore, he alleged that Reinoso and his clique were interested in selling lots at high prices. On December 22, 1589, the Real Audiencia gave its permission to continue the subdivision, and in the week following concessions were made, but almost exclusively to the principal families, the members of the Cabildo, or city council, taking the choice locations. On December 29, 1589, the committee in charge of the division decided, after all, that smaller plots would be granted from then on. The entire council changed in January, 1590, and the subdivisions abruptly stopped.

The new Procurador, Miguel Baltazar de Vedoya, in a letter dated February 6, 1590, protested most energetically against the subdivisions made by the preceding council, which he accused of acting contrary to the decree of the Real Audiencia. This latter body, he felt, would not have approved the acts of the council:

> I plead and supplicate and, if necessary, although speaking with all deference, I require that your Honors declare null and void everything done by the preceding Cabildo prejudicial to the said commons, and that when these are divided with the permission and by the request of the Real Audiencia and Your Majesty, that there be levied each year and on each piece of land given an annual rent and perpetual tribute as income on the public lands of this city; and be it said that if this city must have tierra de pan (land for bread) it is even more necessary that it have grassland for pasturing cattle. . . .
>
> May the Real Audiencia and Your Majesty grant the power to subdivide these Ejidos as I have suggested, which is with tax and perpetual rent for this city, to be paid each year, the amount of rent being determined and adjusted at the time of the subdivision according to the quality of the soil and the value of the land; in which acts I demand that justice be done.[5]

[3] Fray Alonsode Zamora, "Historia de la Provincia de San Antonio," Caracas, 1930, p. 255.

[4] Tulio Febres Cordero, Archivo de Historia y Variendades, Caracas, 1930, Vol. I, p. 183.

[5] Tulio Febres Cordero, "Decades de la Historia de Mérida," Mérida, 1920, Vol. I, pp. 170–172.

CLAY PIT WITH THATCHED ROOF AND BRICK KILN

IN THE PIT OXEN TRAMPLE THE CLAY TO THE PROPER CONSISTENCY. THE OWNERS OF THE KILN ARE BEGINNING TO USE COAL FROM THE MINE AT SAN CRISTOBAL.

THE WOOD HAS BEEN SPLIT; THE KILN IS BEING FILLED WITH LIMESTONE

IN ORDER TO BE READY FOR FIRING. DURING THE THREE DAYS AND NIGHTS NECESSARY IN THE BURNING OF SOME TWENTY TONS OF LIME, ALL THIS WOOD IS CONSUMED.

Nothing seems to have been resolved at the time, but during the colonial times the public lands gradually diminished in extent, the most powerful families taking the largest plots, until at present the Ejidos, known as Llano Grande, have been reduced to not more than an eighth of their original extent. Even as late as the nineties of the last century, when the question arose of selling some parts of the Llano Grande for the purpose of straightening boundary lines, the wall of the local legislature was decorated with these verses:

La tela del Llano Grande	(The cloth of Llano Grande,
Es de trama singular,	Of very curious weave,
Es una tela inflamable,	Is an inflammable material
Peligrosa de cortar.	Dangerous to cleave.)

Fray Alonso de Andrada, of the order of Santo Domingo, came with Captain Suarez as chaplain, and was in Mérida from its founding. The Indians on the encomiendas received the Holy Faith from the Padres, who were wont to hold mass in the open before large groups of Indians. A convent was founded in 1567 and it received the tax on wine and oil from the Royal Treasury from 1570 on. The city was ecclesiastically in the jurisdiction of the Archbishopric of Santa Fé de Bogotá. Fray Rodrigo de Andrada, Prior of the Dominican Convent, had been a companion of Las Casas in his missionary labors as well as in his defense of the Indians against the greed of some Spaniards. Mérida was fortunate in having this humanitarian among her early churchmen.

OPEN MARKET IN MÉRIDA ON A MONDAY MORNING
NOTE DEFORESTATION ON THE SLOPES OF THE MOUNTAIN IN THE BACKGROUND.

Conquerors always wish to impose their language on the conquered. The conquering Romans in the Mediterranean world and the conquering Incas in Peru had this desire in common. Carlos Quinto commanded that schools be founded in which Spanish be taught, and even decreed that the use of the native languages in the Nuevo Reino de Granada be prohibited. This decree was later annulled, and the priests were requested to learn the native dialects—a

YOKE OF OXEN ON THE MOUNTAIN TRAIL NEAR LA CULATA
DRAGGING A HUGE LOG TO THE LIME KILNS AT LA MILLA.

boon to the later students of the languages of the American Indians.

We read in Zamora, "But since insistence with assistance overcomes great difficulties, the padres, using interpreters, convinced those who opposed their teachings, and baptized many." As early as 1696, according to Zamora, the native language was little used around Mérida, yet as late as 1880 some of the

PEASANTS FROM LA CULATA ON THEIR WAY TO MARKET IN MÉRIDA

old pure-blooded Indians from outlying villages still conversed in the native dialect. But the present generation uses only Spanish.

In 1785 a school was established by decree of Carlos III under the headship of the Franciscan, Fray Juan Ramos de Lora. After many changes this became, in 1883, the University of the Andes, where at present three to four hundred students are matriculated, mainly in the colleges of law and medicine.

Thus Mérida has played the role of advance post in the diffusion of the Spanish language and culture as well as of the Roman Catholic faith.

Under Spanish hegemony there were four classes of subjects in Latin America: Spaniards born in Spain, who were qualified for all public offices and who enjoyed other special privileges; "criollos," people of Spanish blood, born in the New World, to whom the high government positions such as Viceroy, Governor, Captain General, were closed; Indians, who were directly governed by special officers within their tribes or towns, and who under no circumstances were eligible for any office except in governing their own people, who were considered somewhat as minors, or special wards of the colonial government; slaves, or Negroes, who, even if free, were a race deprived of all rights and privileges. They were not allowed to marry either Indians or Criollos.

The advantage of belonging to one of the first two classes mentioned above is readily seen by reading the regulation which was promulgated in 1789 by the Procurador of Mérida, Gerónimo Fernandez Peña:

> I command that no person of any class, state, or condition whatever carry weapons such as poniard, dagger, knife, or lance, under penalty, if the person be distinguished, of eight days in prison and four pesos fine; if the person be a plebian, fifty lashes and one month's forced labor, fettered with leg irons.

Undoubtedly one of the main reasons for the loyalty of the Criollos to the cause of the Revolution was their hope of being able to hold the good government posts. But when Bolivar envisaged a great Confederation of States the Venezuelan Criollos, fearful of losing privileges almost within their grasp, refused to recognize his authority, ousted him from Venezuela, and voted that his name be consigned to oblivion. In all justice it must be recorded that the first monument to Bolivar was erected in Mérida in 1840, by the government of the Old Province of Mérida—an example of that independence of spirit which so often characterizes mountain communities.

A LIME KILN NEAR LA CULATA

THE PACK MULES ON THE TRAIL BEYOND THE HOUSE ARE LADEN WITH CHARCOAL FOR THE MÉRIDA MARKET. THE LOWER SLOPES OF THE MOUNTAIN BEYOND THE ALLUVIAL TERRACE ARE GRADUALLY BEING DEFORESTED.

The pre-conquest Indians of the Venezuelan Andes wore few clothes. Some wore narrow belts of cotton which were probably of Chibcha manufacture from

A NARROW BRIDGE OF NATIVE CONSTRUCTION

ACROSS THE TURBULENT UPPER MUCUJUN RIVER. THIS PEASANT WOMAN AND HER TEN-YEAR-OLD SON CARRY CANS OF MILK TO MÉRIDA EVERY MORNING—A FIVE-HOUR ROUND-TRIP.

TWO MULES LADEN WITH DOMESTIC CHEESE (*QUESO CRIDLO*)

WHICH IS FROM THE TIERRA FRIA, ON THEIR WAY TO MARKET.

Bogotá. The Indians probably did not know how to make cloth.[6]. The Spaniards introduced looms, and employed many of the Indians of the encomiendas in small textile factories. The introduction of sheep made possible on a large scale the manufacture of woolen blankets. In 1832 the Governor of Mérida announced that the state was self-sufficient in the production of cloth. Even as late as 1870 cotton cloth was still manufactured in Tabay. In outlying villages, tributary to the Mérida market, such as Mucuchíes, Aricagua and El Morro, woolen blankets are still made, but mainly for local consumption. The outsider who wants a poncho, or covija, must order it a month or so in advance.

In the old geography books one reads that one of the most notable of the industries of Mérida was the manufacture of rugs and carpets, which were of excellent quality. The fine rug, in an excellent state of preservation, that covers the platform of the altar in the new chapel, Cristo de la Matriz, in Ejido, dates from 1815 or 1820. But the rug industry has completely disappeared.

It seems incredible, but as early as 1579 Mérida exported hams. It is not surprising that the first Spaniards in the Andes should have been interested in raising hogs, since they came from Estremadura in Spain, a province famous for its pork sausages; but that they should have been able to raise and fatten hogs in large quantities is the striking thing. What they were fattened on we are not told.

Formerly the manufacture of candy in the region of Mérida was a thriving industry. As late as the eighties sweetmeats and bon-bons were transported by mule trains as far as Tocuyo and Barinas, at the edge of the Llanos.

Wheat, one of the first crops introduced into the Venezuelan Cordillera by the Spaniards, gave abundant yields and soon became an export crop. In 1579 two of the founders of Mérida promised the merchant Antonio Amezaga 1,000 arrobas (an arroba is 25 pounds) of flour at half a peso the arroba, laid down in any of the Lake Maracaibo ports. In the same year ships laden with flour biscuits and fruits coming from Mérida left ports along the south shore of Lake Maracaibo for Cartagena and the Antilles. Fray Pedro Simón, in speaking of the crops grown around Mérida, says, "but the most outstanding one is wheat, which gives heavy yields of good quality in the tierra templada (temperate region). Flour is shipped out to Cartagena by the frigates which enter Lake Maracaibo twice a year, calling at the port of Gibraltar, where it is stored in warehouses which have increased in number till the port has become a city. To-day it is the most famous port in the Indies because of the great quantity of fine tobacco which it exports from the city of Berinas."

But the methods of cultivating wheat have not changed in centuries. In Mucuchíes the fields lie fallow a year and are then again planted in wheat. Artificial fertilizer is little used because of the expense. There is very little animal manure to be had because of the small number of domestic animals. The ripe grain is trampled out on circular threshing floors by the hoofs of horses, just as it was in the time of the early Spaniards, and is to-day in many parts of the Mediterranean world.

After the War of Independence Venezuelan wheat was used only in the Andean provinces and in the neighboring states of Zulia, Lara and Barinas. It is estimated that in 1876 the State of Mérida produced 80,000 100-pound sacks of wheat, and as late as 40 years ago great quantities of wheat arepas (tortillas) were brought to the Mérida market from Mucumbá, Mucuchíes and El Morro, where they were sold at a penny apiece. With flour costing the equiva-

[6] Julio C. Salas, "Tierra-Firme," Mérida, 1908, pp. 44–45.

A PRIMITIVE LUMBER MILL NEAR MÉRIDA
IT TAKES TWO MEN A DAY TO SAW A TEN-FOOT LOG, 18 INCHES IN DIAMETER, INTO PLANKS.

lent of 8 to 10 cents a pound the arepa one could now buy for a penny would not make a small mouthful.

Cacao, cane sugar, indigo and cotton also were formerly exported from the Chama valley, but can no longer be produced cheaply enough to compete successfully with the large-scale mechanized production in other countries. Enough cacao and cane sugar are produced for local consumption. Indigo has long since been supplanted in its uses by the aniline dyes.

There is a reason for this decline in the exports of agricultural produce. Hams, flour and biscuits were produced by slave or serf labor and exported only to the mother country, in a closed economy. The Spaniards were not at all interested in the standard of living of the producers. When slavery and serfdom were largely abolished these products were consumed locally instead of being exported. The parallel with modern totalitarian economies is close. It is possible to export manufactured goods—or even agricultural products—in great quantities, if labor has only to be fed and housed, paid in last analysis out of the standard of living of those not producing for export. Since 1918 the mercantilist economy, streamlined for twentieth century consumption, has again become popular after a long rest.

On October 18, 1600, the Real Audiencea de Santa Fé voted 696 pesos to be used in building a church in Mérida. The man in charge of the construction was Don Juan de Milla, one of the first colonial architects in Venezuela. Don Juan built his brick, tile and lime kilns along the edge of the small stream which enters the Albarregas just east of the town, now known as the Milla. This was the beginning of those local industries which are still very important in the economic life of the town, and in which a great deal of local labor finds employment. Unfortunately, tremendous quantities of wood are used during the process

of burning and the use of coal from the mine at San Cristóbal is very recent. It now costs some $12 a ton laid down at the kilns. The great logs which are cut up for firewood are still dragged by oxen many miles over rough trails from the high mountains to the kilns for four Bolivares. It is to be hoped that this practice will be stopped before the forests are completely destroyed.

Mérida throughout its history has been a political and administrative capital. The town, separated by many weeks or, formerly, months from Bogotá, in whose jurisdiction it was almost till the end of the colonial period, soon achieved a kind of local autonomy. The central government, whether located in Bogotá or Caracas, was too far away to be consulted on every issue, so that the administrators themselves assumed the responsibility of making decisions on most local matters. But the salaries of government officials, both state and federal, have been important locally in fostering trade and industry.

One visit to the open market held every Monday morning will convince the visitor of the importance of Mérida as a trading center. Products of the several climatic regions arrive in trucks or on the backs of burros, oxen or human beings. From the tierra caliente down valley come plantains, melons, avocadoes, cherimoyas, medlars, cacao, yuca, arum roots and great pots of black paste, the tobacco extract known as chimo; the tierra templada supplies turnips, cabbages, tomatoes, beets, carrots, rue, cauliflower; potatoes, wheat flour, wool and huge cheeses wrapped in the velvety leaves of the giant dandelion, frailejón (*Espeletia Schultzi*), come from the tierra fria, the high cold mountain slopes. Thus the real role of Mérida is that of market town for a region composed of several climatic zones. It will never entirely lose its rural aspect. Small storekeepers and business men often have their real wealth in a piece, or several pieces, of land within a radius of 20 to 30 miles of the town. Many

A TYPICAL MOUNTAINEER IN FRONT OF HIS HOME

HE WAS AT THE UPPER LIMIT OF CULTIVATION ON THE LEFT BANK OF THE CHAMA, NEAR MÉRIDA. HIS FARMING TECHNIQUES WERE MOST PRIMITIVE: HE KNEW NOTHING OF CROP ROTATION, MADE NO USE OF FERTILIZERS, AND FOUND OUT WHERE CROPS DID BEST BY TRIAL AND ERROR.

MÉRIDA, WITH ROOF OF MOUNTAINEER'S HOUSE IN FOREGROUND
EVEN AT THIS ELEVATION PLANTAINS STILL GREW. THE PEASANT, FOND OF THE VIEW FROM HIS HOUSE, WAS HAPPY THAT ANOTHER COULD APPRECIATE IT TOO.

ranchers from the tierra caliente are happy to spend the less active years of their life in the mild climate of this Andean capital. They live in unpretentious homes on the quiet streets, and lead very peaceful lives, except in political discussion.

The tierra fria is a great human reservoir where large families are the rule—families of 12 to 15 living children are common. In spite of terrible living conditions the infant mortality is relatively low. The air and water are pure; malaria and dysentery are unknown; the actinic rays of the sun are strong enough in the rare atmosphere to make rosy cheeks on dark skins. Crops ripen slowly, however, and the soil gives niggardly. In this purely agricultural region the population increase is much greater than the possible increase in the production of food. As the pressure of population increases there would seem to be only one safety valve, emigration, and there is only one direction to emigrate, and that is down. Very frequently the mountaineers settle on what the more fortunate people of lower-lying areas consider marginal land—along the upper limit of cultivation. Or they migrate to the towns, where they become skilled, industrious workmen. As Pedro Simón remarks, "The Andinos stand out above those of the other Spanish provinces in that both men and women are large of build, the children are healthy because of the temperate climate, and they have very keen minds." The most casual tourist is struck by the difference in appearance of the sallow, malaria- and dysentery-ridden people of the lowlands and the robust, energetic Andinos. Furthermore, one sees many old people in the mountains. An old person is a rarity in the lowlands.

During the past century almost every one who had soil on which coffee would grow planted that crop, considering it a kind of modern El Dorado. More and more land and energy were devoted to

the growing of coffee, whereas the raising of plantains, yuca, potatoes and cereals was neglected till they became scarce and correspondingly expensive. But one-crop systems of agriculture are apt to be instable, a kind of Damocles sword over the head of a nation. King Coffee was dethroned by nations of large-scale mechanized production. Many coffee plantations at present are being transformed into cow pastures, since in the past decade a ready market for dairy products has developed. Coffee can no longer be profitably exported except when heavily subsidized by the Federal Government, payments made possible in last analysis by the receipts from oil exports. When this source of income dries up the producer of foodstuffs will again play an important role in the regional economy. It is to be hoped that the "dead hand" of the system of latifundios, or great landed estates, will be partly or wholly lifted from the Chama valley—indeed from all of Venezuela.

The last important factor in the evolution of Mérida was the building, for wheeled vehicles, of the great Carretera Transandina, a part of the 2,295-mile-long Simón Bolívar Highway that stretches across Venezuela, Colombia and Ecuador from La Guayra to Guayaquil. (2,018 miles are completed and the remaining 277 are usually passable in fair weather.) Up to 1926 a trip from Mérida to Caracas was an ordeal lasting a week or ten days: three days on horseback to a Lake Maracaibo port, thence embarcation on a lake steamer to La Guayra. Now the trip can be made in motor car in two days. Since the completion of the Maracaibo-Mototán highway Maracaibo is only a day's ride from Mérida. One of the results of the linking up of Mérida by highways with the outside world is the development of tourism. It will benefit further when the Apartados-Barinas highway is completed. The increased movement has meant more money in circulation, and the most obvious result is the present building boom in the town, which is only beginning to reap the benefits of being in easy communication with the rest of the country.

In the Mediterranean world the area under cultivation around a town is often but the extension of the urban agglomeration, the founding of which took place in hoariest antiquity. Or it may be that the city does not have areas of intensive cultivation near it, as is true of Rome and Madrid. Such cities seem to the casual observer to have little geographic raison d'être. But in the mountains of Latin America the regional unit often sprouts, as it were, its own capital, particularly if the unit embraces various climatic zones or belts, as does the valley of the Chama River. The beautiful mesa on which Mérida is located, midway between tierra fria and tierra caliente, is an ideal site for inter-regional exchange. A detailed study of the valley of the Chama, from Mucuchíes to Laguinillas, only brings home to the student the fact that upon this mesa a town would almost inevitably come into being. One can not but admire the vision of the Indians, who were already well established there when the Spaniards came. And the Conquistadores were quick to realize that both the site and position were ideal for the development of an Andean capital.

Prefiero ser árbol, mejor que ser rama;
Prefiero ser leña, mejor que ser humo.
Y al viaje que cansa, prefiero al terruño;
La ciudad nativa con sus campesinos;
Ventanas arcaicas, vetustos balcones,
Y calles estrechas, como si las casas tampoco
quisieran separarse mucho.

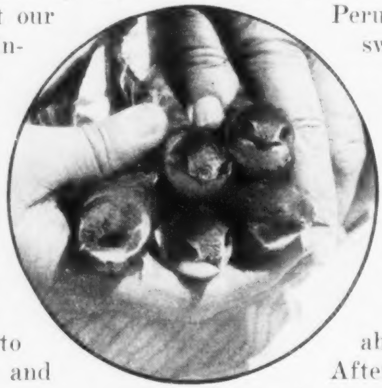
(I prefer to be a tree, rather than a limb;
I prefer to be firewood, rather than smoke;
And to the tiring voyage, I prefer my homeland,
My native town and its farmers nearby;
Old fashioned windows and archaic porches,
And narrow streets, as if the houses themselves
wanted to keep close together.)

—*José Santos Chocano*

BIRD STUDY THROUGH BANDING

By Dr. DAYTON STONER
STATE ZOOLOGIST, NEW YORK STATE MUSEUM

WHEN Mrs. Stoner and I began banding bank swallows in 1923, we little thought that this work and the studies incidental to it would be continued for the succeeding eighteen seasons, or that 6,834 individuals of this species would be fitted by us with the numbered metal bands of the United States Bureau of Biological Survey (now the Fish and Wildlife Service of the United States Department of the Interior). Much less did we anticipate that we should be able to obtain 247 returns from the swallows that were banded by us, nor did we then suspect that our investigations would include such features as temperature of the birds and their burrows, weight of adults and young, food habits, behavior, longevity and family relationships. As a matter of fact, these and several new or little known matters relating to the ecology, life history and behavior of this swallow were suggested through the utilization of the banding method as the avenue of approach.



Our bank swallow banding work has been carried on in three rather widely separated localities, Lake Okoboji, Iowa, and Oneida Lake and Albany, New York. Of course one of our principal objectives has been to band as many individuals as possible so that the likelihood of recoveries might be correspondingly enhanced. In addition, we have attempted to utilize each recovery to the fullest extent and from several different view-points, but at the same time to avoid confusion and lack of progress by tempering the inclination to cover too much territory.

Before considering any of the concrete results of our bank swallow banding activities, it will be well to recount briefly the essential features in the life history of this bird. In this sketch I shall incorporate certain of our own findings as well as others more commonly known.

The bank swallow is a widely distributed, migratory bird which breeds from Alaska south to Texas and Virginia. It migrates through Mexico and Central America and winters in Brazil, Peru and Argentina. This swallow also occurs in Europe and the British Isles, where it is commonly known as the sand martin.

In the Oneida Lake, New York, region bank swallows usually begin to arrive late in April and attain maximum abundance by May 20. After a period of preliminary reconnoitering during which they course about over the countryside, pairing occurs and within a few days the birds take up nesting territory in the precipitous banks of streams and sand pits.

Excavation of the burrow is the first work to be accomplished, and both sexes take part in this activity. At first the swallows cling to the bank and peck away a few grains of sand at a time until a slight concavity is formed; using this as a point of vantage these energetic feathered excavators dig away with bill and claws until the future habitation acquires some length. As the loose sand

falls to the floor of the burrow it is literally kicked out by the swallows or sifted out by rapid movements of the partly folded wings.

The speed at which excavation is carried on depends somewhat upon the state of the birds' reproductive organs; ordinarily it progresses at the rate of 3 to 4 inches a day, for the average burrow which varies in length from 24 to 36 inches. The longest burrow that we have found measured 65 inches.

Nest construction follows immediately; this work also is shared by both sexes. The basic nest materials usually consist of grass and weed stalks—both green and dried—straw and rootlets; most of this is secured while the birds are on the wing. Some of the materials are so long—20 to 25 inches—and bulky that one wonders how so small a bird can manage such heavy and unwieldy objects.

Shortly after the unlined foundation nest is completed, the female sits in it preparatory to laying the eggs. During this period, as well as in the early stages of incubation, the male often sits on the edge of the nest by her side. The first eggs and sometimes all in the usual clutch of 4 or 5 are deposited in the unlined nest. As incubation proceeds, feathers—usually white ones from the domestic fowl—are added as a lining so that by the time the young are hatched a cozy bed awaits them.

The eggs are white and the average weight is 1.4 grams. Fourteen to sixteen days are required for incubation; this activity is shared by both sexes.

At the time of hatching, the young are practically naked and small (average weight about 1.3 grams); for several days they require constant brooding, feeding and other care on the part of the parents. Body and feather growth are very rapid and maximum weight is attained in thirteen to sixteen days.

Usually the young attempt their first flight 19 to 21 days after hatching. In these initial attempts the birds exhibit remarkable wing control and maneuvering ability, but they lack endurance and do not long remain aloft. Although now adept in flight, for several days these immature swallows receive some degree of ministration from the parents. However, within a week the adults largely desert the burrows; a few resume nesting activities incident to the rearing of a second brood.

For a few days following initial nest-leaving the young make short flights into the surrounding territory. Although they usually continue to return to the home colony at night, they are as likely as not to enter other burrows as the ones in which they were reared. In other words, family relationships are more or less completely broken following first flight of the young. We have found immature banded repeats from as many as three different families in a single burrow. Gradually the young wander more widely and may roost in a colony some distance from the parental one. Within ten to fourteen days they desert the immediate scene of their natal home, and by August 1, or even earlier, begin flocking in swamps and similar situations preparatory to the southerly migratory movement which is often initiated a fortnight later.

Reasons for and Nomenclature of Banding

For several of the types of study undertaken by us and now to be mentioned in some detail, it was desirable that the birds be marked in some permanent manner so that, if and when they were subsequently recovered, we should be certain of their identity. The small numbered aluminum bands furnished by the U. S. Fish and Wildlife Service best meet the requirements.

A bird recaptured the same season that it was banded and in or near the territory occupied by it when banded is termed a "repeat." A bird recaptured at some distance from the point of banding in the same or a subsequent season

or in any locality after at least eight months have elapsed between the time of banding and the time of recovery or between two or more recoveries is designated as a "return." It is assumed that in each eight-month period the swallow completed the round-trip journey between its nesting territory and its winter home. If a return is captured more than once in a season it is called a "repeat return"; the second time that a bird is captured as a return it is designated as a "return-2," the third time as a "return-3."

Method of Capturing Bank Swallows

One of the advantages associated with the banding of bank swallows is that their nesting burrows can be utilized as traps to capture the occupants. Best success in capturing adults is likely to come during the height of the egg-laying period and the early days of incubation. In the Oneida Lake region we have found this to occur between May 20 and June 1. As indicated above, during this activity the male and female often occupy the burrow at the same time; not infrequently the pair can be taken together. In the later days of incubation usually only a single adult is found in the burrow at any one time.

Of course after the young are hatched the burrow also serves as a "gathering cage" for the bander. A small trowel may be used to carefully enlarge the burrow so that the investigator's hand and arm can be introduced for withdrawal and replacement of the nestlings. Young birds ready to fly can be flushed in the same way as the adults. Adult birds may abandon a nest if disturbed too much while it contains freshly laid or slightly incubated eggs, but only under extreme provocation will they desert one containing well-incubated eggs or young.

On cloudless days the observer, by using a small hand mirror, can throw a beam of light from the sun into the burrow, thus illuminating its interior sufficiently to count the eggs or birds and to study other features. On cloudy days an ordinary flashlight of the "pencil type" can be attached to a stiff wire and inserted into the excavation. If the burrow is found to contain adults a small gauze bag, held open at the large end by a ring of pliable wire, is quickly placed over the burrow mouth and fastened in place with two or three small hooked wires forced into the sand. After a longer or shorter period of watchful waiting, the swallows usually dart into the bag from which they are immediately rescued for observation and banding. Sometimes a little persuasion in the way of a long wire introduced into the burrow or the continued flashing of a beam of light into it with the mirror will cause the occupants to emerge. A light pounding on the turf above the burrow or on the face of the bank near its mouth sometimes produces the desired results.

Marital and Family Relations

Although, on the basis of external characters, it is impossible to distinguish the sexes in the bank swallow, we have banding evidence that both polygamy and polyandry sometimes occur in this bird. Moreover, in none of the several instances in which both members of a nesting pair have been captured as returns have we found the same individuals mated for a second time. While this swallow occasionally nests twice in a season, all of our return and repeat records indicate that new partners are taken for each nesting whether in the same or a different season.

Weight Studies

One of the important fields of ornithological investigation that has been stimulated through bird banding is the determination of the weight and its fluctuations for many species of wild birds. In most of our bank swallow work we use a triple-beam laboratory

THE OPERATOR INSPECTS THE INTERIOR OF A BURROW
WITH THE AID OF A BEAM OF LIGHT REFLECTED FROM THE SUN BY A SMALL HAND MIRROR. THE WHITE DOTS ON THE FACE OF THE BANK ARE TAGS BEARING BAND NUMBERS OF THE BIRDS INHABITING THE BURROWS. THE GAUZE BAGS, HELD IN PLACE BY WIRE HOOKS, COVER THE BURROW ENTRANCES, AWAITING THE BIRDS WHEN THEY FLUSH.

balance sensitive to $\frac{1}{10}$-gram and fitted with steel knife edges and agate bearings. To facilitate portability and render its use practicable and accurate on windy days, the instrument is housed in a wooden carrying case.

For 396 different adult bank swallows of both sexes captured between May 10 and July 20 the average weight was 14.3 grams, with a minimum weight of 11.8 grams and a maximum of 20.3 grams. Fourteen and three-tenth grams is the approximate equivalent of one-half ounce, or about the weight of four sheets of this publication.

From an average weight of 1.3 grams —roughly 1/28 ounce—at the time of hatching, young bank swallows attain the average maximum weight of 16.5 to 19.5 grams in 12 to 17 days. This is greater than the average weight of fully mature individuals.

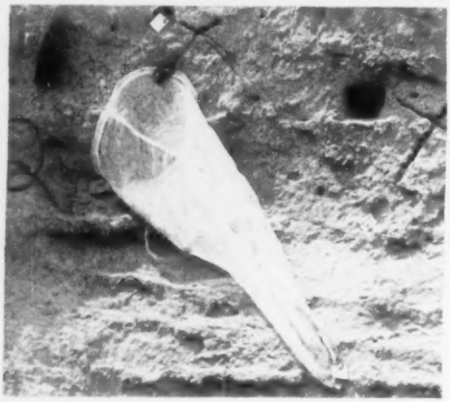
From about the sixteenth day after hatching to the time of leaving the nest the young lose from 1 to 4 grams in weight. And, even at the time of initial flight, they average heavier than the adults. This recession in weight during late nestling life characterizes all the swallows, but the phenomenon apparently is not shared by many other passeriform species.

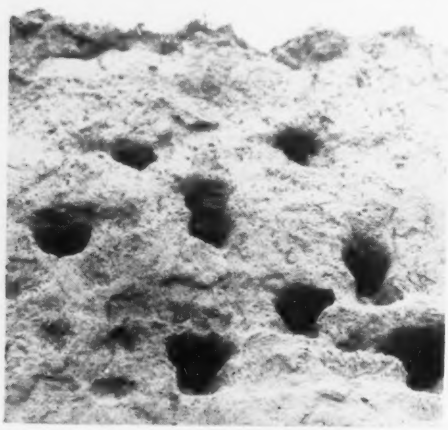
Temperature Studies

In our investigations of the body temperature of bank swallows a specially constructed, non-self-registering mercury thermometer is used. This instrument is 6 inches long, $\frac{3}{16}$ inch in diameter and extremely sensitive. Within a few seconds after it is inserted down the throat and into the proventriculus of the subject, it registers the temperature and thereafter, as long as it remains in place, any changes or fluctuations in bodily heat that may occur, without the "shaking down" so characteristic of the self-registering type of clinical thermometer used on human subjects.

The "normal" body temperature of most birds is considerably higher than that of man and the avian mechanism for regulating body heat is much less efficient than our own. On this account, rather remarkable variations and fluctuations in the temperature of birds may occur. It is perhaps more proper, therefore, to speak of "normal temperature range" in birds.

For adult bank swallows, the indi-





BANK SWALLOW BURROWS
Top: GROUP OF BURROWS NEAR THE TOP OF A HIGH BANK. *Middle:* A GAUZE COLLECTING BAG HANGS OVER A BURROW. THE TAGS AND SYMBOLS SERVE AS IDENTIFICATION MARKS. *Bottom:* A CLOSE VIEW OF SEVERAL BURROWS.

vidual variation in temperature may range from a minimum of 90° F. to a maximum of 112° F. Readings that we have taken on 734 different adult birds of both sexes at all hours of the day between 8 A.M. and 9 P.M. indicate that the average ("normal") temperature is 107.4° F.

At the time of hatching the young bank swallow is essentially a cold-blooded animal, just as were the reptile-like forms from which it has descended. Within a few days, however, its temperature control mechanism begins to function more efficiently and the body temperature becomes higher and more constantly maintained. We should expect to find, then, that variation in the temperature of young bank swallows is more marked than in adults. Our investigations have shown that a range of more than 25 degrees may occur in them, with a surviving maximum of 115° F. and a minimum of 90° F.

In order to illustrate the way in which the temperature of young bank swallows increases as they grow older, I present a brief summarization of our records. For this purpose the birds have been allocated into four principal age groups.

The average body temperature for 116 nestlings (age 1–4 days) was 99.8° F.; for 174 fledglings (age 5–9 days) 102.5° F.; for 89 juvenals (age 10–15 days) 104.5° F.; and for 122 immatures (able to fly well) 106.2° F.

It will be noted, therefore, that the average temperature for young birds at about the time they leave the nest is approximately one degree less than the average for adults, and that the average rate of increase in body temperature in young birds is about 0.5 degree a day until flight ability is attained.

RETURNS AND THE "HOMING INSTINCT"

A little more than 4.5 per cent. of our banded bank swallows known to be available for returns have been recovered as such. Of course the assumed number of birds thus available in any season includes only those banded in previous seasons—less the number known to have

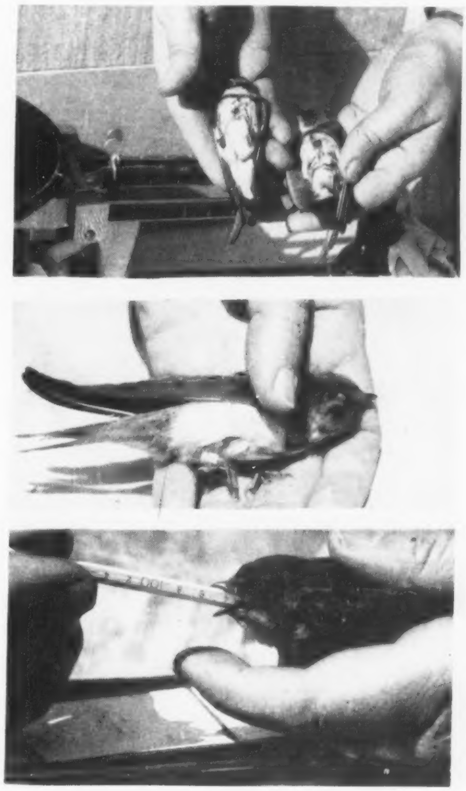
been killed or otherwise removed from consideration.

So far as we are aware no other person has ever captured one of our banded bank swallows. Moreover, the great majority of our return bank swallows have been recaptured by us in the same colony as banded. No individual has been taken at a greater distance than 12 miles from the point of banding; in the extreme case the bird was banded as a fledgling and recovered the next year as a breeding individual. Several of our recoveries have been "return-2's," that is, recovered as returns in two different breeding seasons but, to date, only one swallow carries the distinction—or ignominy—of having been captured as a return in *three* different seasons. A brief account of the known history of this bird will be of interest.

Incubating adult bank swallow No. F-55924 was banded from a burrow in the bank of a creek about three miles east of Oneida Lake, New York, on June 2, 1932. On May 26, 1934, it was recovered, incubating, in the same colony; on May 21, 1935, it was again recovered as a nesting individual in that colony; and on May 22, 1936, it was recovered, dead, in the same colony as before and in a burrow within a few feet of the one occupied by it in 1934. At the time of its death the known age of this bank swallow was 10 days less than five years; it had made at least five round-trip journeys between its nesting ground and its distant winter quarters and nested four seasons—at least three of them successive—in the same sector of the same colony; it had a different mate in 1935 and 1936; it was attacked and partially eaten by a brown rat as it was laying or incubating in a burrow within a few feet of the one occupied by it at the time of original capture.

Usually the bank swallow burrows of one season do not carry over to the succeeding nesting period. Weathering of the sandy soil causes the burrows to become obliterated either through filling up with sand or slipping of the banks. In at least two instances, however, we have found a banded swallow occupying the same burrow on two successive seasons.

One of our most interesting groups of returns was obtained in 1939 from five laying or incubating birds recaptured at one field station on an expanse of bank



ADULT BANK SWALLOWS
Top: TWO SWALLOWS LIE UNRESTRAINED IN THE OPERATOR'S HANDS. *Middle:* THIS BIRD WAS BANDED AS AN INCUBATING ADULT JUNE 13, 1938; RECOVERED IN THE SAME COLONY, BUT WITH A NEW MATE, JUNE 3, 1939. *Bottom:* A THERMOMETER IS INSERTED IN THE THROAT OF BIRD.

approximately nine feet long and six feet high. This is the greatest concentration of returns that we have encountered. Three of these swallows were banded in this colony in 1938 from burrows situated within a few yards of one another, while

the other two also were banded in 1938 but from rather widely separated burrows in a colony about one-half mile northwest of the point of recovery. It is interesting to speculate as to whether these birds remained more or less together during their migrating journeys and in their South American winter home and what—if anything—may have prompted three of them to return to nest in almost the same spot in the same colony which they occupied the preceding season while two others from a near-by colony took up nesting quarters in such close proximity to them. Surely something more than mere chance is responsible.

An analysis of our bank swallow return records indicates that first year birds do not often return to breed in the *colony* in which they were reared, but more frequently they do return to the *general region* of their nativity to rear their young. On the other hand, a large proportion of adults return to breed in the very colony in which they previously have nested and a still larger proportion return to the same general region after they once have nested there.

Here are the figures for the evidence: Of 35 birds banded as young and recovered as returns, only 9 (26 per cent.) had taken up domiciles in the same colony as reared. Of 212 birds banded as adults and recovered as returns, 170 (80 per cent.) were nesting in the same colony as banded. Furthermore, in each of the three localities where we have conducted bank swallow banding operations practically all our work has been done within a ten-mile radius wherein only 15 per cent. of the returns have been obtained from birds banded as young, while 85 per cent. of the returns have been derived from individuals banded as adults.

Longevity in the Bank Swallow

Bank swallows evidently are comparatively short-lived birds. Mortality among them appears to be very high, especially during the first year, while an individual that has survived to the ripe age of six years is a Methuselah of his kind. In the following tabular summary our 247 returns are grouped according to their known or approximate ages.

Approximate age	1 year	18
	2 years	146
	3 years	53
Known age at least	4 years	20
	5 years	9
	6 years	1

It would appear from this that the probable average life span in bank swallows is two to three years; only 12 per cent. of all our returns had attained a known age of as much as four years, while 80 per cent. of these returns are for individuals of a known age of two and three years.

Among the more important destructive agencies of the bank swallow, so far as both young and adults are concerned, may be mentioned slumping banks and the depredations of skunks. These animals frequently dig into the burrows from above and feed on eggs and birds of all ages. Foxes sometimes dig into the nests from the face of the bank, and swallows nesting in the vicinity of farm buildings are often attacked by brown rats which climb the slightly sloping or rough banks to enter the burrows and feed on the birds in all stages from egg to adult. Crows and marsh hawks are serious enemies of bank swallows during the nesting season, when they attack the adults while they are carrying food to the young or leaving the burrows after delivering it to them.

The several types of inquiry that we have conducted on the bank swallow through use of the banding method, not only have contributed to our knowledge of this bird but also may suggest lines of endeavor that can be undertaken with profit on other species. Worthwhile results are sure to attend earnest effort.

RADIATION PATTERN OF THE HUMAN VOICE

By D. W. FARNSWORTH
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RADIO antennas, microphones, loudspeakers, or any apparatus that either emits or receives radiations has a directional characteristic or radiation pattern, and the determination of these patterns is one of the routine procedures in radio and acoustical work. If the device is to receive radiation, the directional characteristic expresses the sensitivity of the device to radiation coming from various directions in space. If the device is to emit radiation, on the other hand, the directional characteristic expresses the power radiated in various directions. In both cases the sensitivity and power in each measured direction may be subdivided into frequencies or frequency bands. In acoustics, the basic radiator of voice sounds is the human mouth, but strange as it may seem there are no known records of any complete determination of the directional characteristic of speech as it is affected by the shape of the mouth, head, and body. This situation has now been partially remedied by an extensive study recently made in these laboratories by H. K. Dunn and the writer.

Perhaps one of the reasons that such a study has not been made before is that it is inherently a much more laborious task than determining the directional characteristics of a loudspeaker or microphone. With a loudspeaker, for example, the characteristic is usually determined for a number of single frequencies, and these are supplied to the loudspeaker from an oscillator giving a continuous tone at constant frequency and volume. There are no other variables but the position of the pick-up microphone, and thus the procedure is comparatively simple. The human voice, however, is a complex assembly of different frequencies at different levels, and in ordinary speech both level and frequency composition vary continuously. Moreover, the source is a human throat, which suffers fatigue; it can not be turned on like an oscillator and run continuously without variation. Determining the distributional pattern of the voice is thus far more laborious and complicated than any of the more usual determinations of directional characteristics.

In securing the spatial distribution pattern of speech, it seemed desirable to average the speech pressures over an interval long enough to insure that the average was typical, and to use as the source of sound a set of words that would be typical of ordinary speech both in the basic sounds employed and in their distribution into syllables. To meet this requirement, J. C. Steinberg devised the following sentences. "The different speech sounds have been moulded into (sentences, such that the consonants and usual compounds occur in the vowel combinations which are met with very frequently in English. For lack of time, it was not possible to get every group included; although, as is shown quite clearly in the figure upward of eighty per cent.) are accounted for. I think nothing else need be said in this place on the subject." Sound pressure was averaged over a 15-second period, which was controlled automatically, and the actual measurement usually covered about that portion of the above quotation included in parentheses. The tests were made in an acoustically treated room so that reflections from the walls would not result in readings that did not

truly represent the direct radiation from the mouth. Because of these precautions, the results are essentially the same as would have been obtained in an open outdoor space entirely free from extraneous sounds.

Besides determining the distributional pattern for whole speech, it was desired also to determine it for various bands of frequencies. In some ways, the narrower these bands, the more satisfactory would be the results, but it was finally decided, largely because of the availability of filters, to divide the range of speech frequencies into twelve bands. The lowest three were each one octave wide, and ran from 62.5 to 500 cycles, while above 500 cycles, the filters were each one-half octave wide except the twelfth, which was a high-pass filter cutting off at 8,000 cycles. The upper frequency is really set by speech itself, which has practically no components above 12,000 cycles.

FIG. 1. TEST CHAMBER
ARRANGEMENT OF SPEAKER AND MICROPHONE FOR DISTRIBUTION MEASUREMENTS.

Limitation of apparatus and of personnel made it necessary to take readings at only one position in space at a time, and of only two frequency bands. This meant, of course, that measurements would have to be carried on over a considerable period of time, since for each of some eighty positions in space seven readings were required to cover all the frequency bands and eight readings were taken for each pair of bands to insure that the value used was representative. Including preliminary and trial readings, a total of 5,000 readings was taken altogether.

With such a protracted study, there would be bound to be variations in the test sentences in volume, not only from day to day but for different sets of readings taken on the same day. It was necessary, therefore, to set some reference volume at some fixed position, and to correct each set of readings for departures from the basic value. To make this possible two pick-up microphones were used for each reading; one was an exploring microphone, which could be moved to the various positions in space, and the other was a fixed microphone. This latter microphone was fastened to the arm of the chair in which the speaker sat, with the diaphragm at one side and slightly below the speaker's lips, and 32 centimeters away. A bracket attached to this transmitter carried a small loop of wire at the end, and the speaker always sat so that this loop just touched his upper lip. The arrangement is shown in Figure 1.

Both of the microphones were of the condenser type with self-contained amplifiers. They are small microphones with diaphragms only 1.8 centimeters in

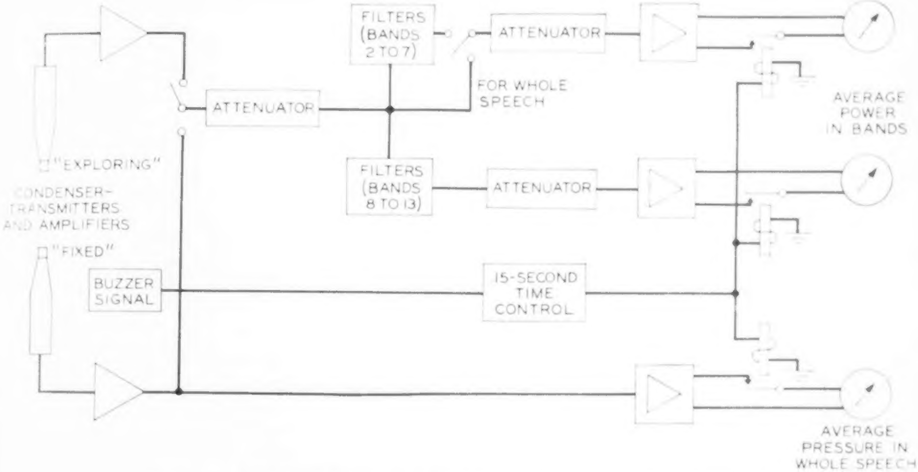

FIG. 2. BLOCK SCHEMATIC OF MEASURING CIRCUIT

diameter, but for positions very close to the speaker's mouth, a "search tube" five centimeters long and only three millimeters outside diameter was used. A block schematic of the testing circuit is shown in Figure 2. For each position of the exploring microphone, four readings would be taken for each frequency band and for whole speech, and four for each band using the fixed transmitter.

Positions in space at which readings were taken are designated by three coordinates, as indicated in Figure 3. One of these, designated "r," is the radial distance in centimeters from the front of the lips; another is the horizontal angle "θ" measured from directly in front of the speaker in either direction around to 180°, directly behind him. Readings were taken only around one side, since it seemed reasonable to assume that because of bodily symmetry, readings on the other side would be the same. The third coordinate is the verti-

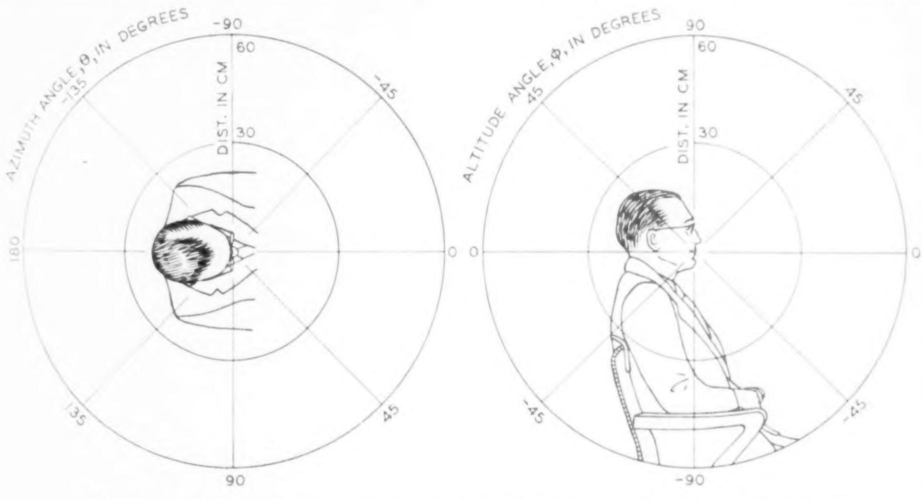

FIG. 3. POSITIONS IN SPACE INDICATED BY THREE COORDINATES:
R, RADIAL DISTANCE FROM THE LIPS; θ, HORIZONTAL ANGLES, AND φ, VERTICAL ANGLES.

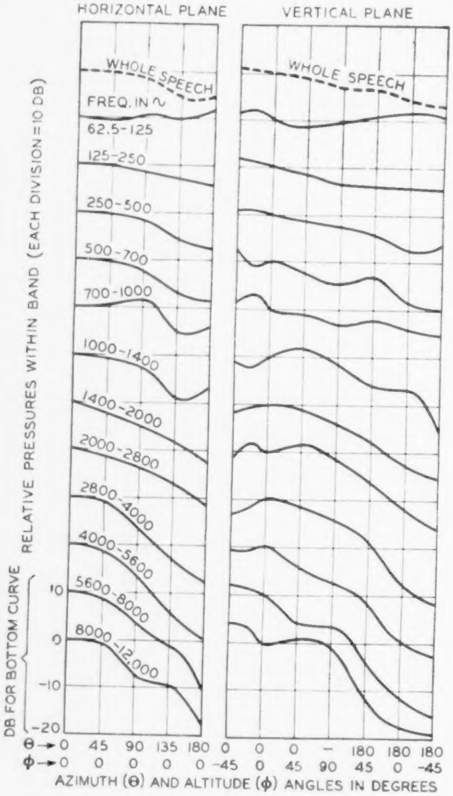

FIG. 4. SPEECH PRESSURES
AT 60 CM FROM THE LIPS AS θ VARIES, AT THE LEFT, AND AS φ CHANGES, AT THE RIGHT.

cal angle ø, measured from zero in the horizontal plane to +90° directly overhead, and to −90° directly beneath the lips.

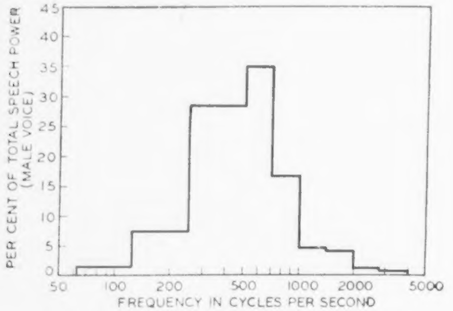

FIG. 5. MALE SPEECH POWER
SPECTRUM OBTAINED FROM AN INTEGRATION OF THE TEST RESULTS. THESE CALCULATIONS ARE PLOTTED IN PER CENT. OF THE TOTAL POWER.

With data distributed over three-dimensional space and over twelve frequency bands, it is difficult to present them in a way to make the distribution of sound pressures evident over the entire volume. The general form of distribution may be indicated, however, by plotting the pressures at some one constant radial distance for each frequency band and for speech as a whole at vertical angle 0° as the angle θ varies from 0 to 180°, and in a vertical plane at horizontal angle 0° as the vertical angle varies. This is done in Figure 4.

Considering first the variation with horizontal angle, it will be noticed that whole speech remains about constant up to 90°, and then falls off. Frequencies from 62.5 to 175 cycles, however, remain practically constant all the way around. For the higher frequency bands there seems to be a progressively increasing reduction in level after angle 45° is reached. This becomes particularly pronounced for frequencies above 2800 cycles. Pressures at frequencies from 700 to 1400 cycles seem to behave in a rather anomalous manner, for which there is no ready explanation. It has been known, of course, that in general the high frequencies are more directional than the low, but this is the first time that actual detailed results have been secured of their directivity when emitted as speech.

Distribution in the vertical plane, shown at the right of Figure 4, evidences more unexpected characteristics. For whole speech and all frequency bands below 1000 cycles, and also for frequencies above 5600 cycles, the pressures are greater at an angle of 45° below the horizontal than they are in the horizontal plane. At a distance of 15 cm where readings may be taken at −90°, or directly below the lips, the pressures straight downward are greater than either at −45° or 0° for all frequencies below 1000 cycles.

Data of this sort are very useful in guiding the placing of microphones, since they show the region over which all frequencies are present in about their true relative proportions, and the amount of equalization that would be required in other locations. A study of these curves shows that a microphone could be placed at any horizontal angle up to about 75° and at any vertical angle from $-45°$ to 90° without the necessity of equalization.

To confirm these conclusions, listening tests were made in which two other positions were compared with a position in front of the speaker. One of these was 60 cm directly above the lips, the forward transmitter being at the same distance, and listeners in another room could switch between the two transmitters. After equalizing the two circuits for loudness, the listeners could not distinguish between the two transmitters. When one of the transmitters was placed directly behind the speaker, however, there was a marked loss of the higher frequencies.

Another advantage of these data is that they may be used for calculating the total voice power, and also the total power in each frequency band. By assuming that the pressure in each direction represents the average pressure extending half way to the next position line in both directions in both horizontal and vertical planes, it is possible to integrate speech pressures over the entire surface of a sphere having its center at the speaker's mouth, and by using a suitable constant to calculate the total emitted power. The error in this basic assumption is probably within the accuracy of the test data. The results of these calculations are plotted in Figure 5 in per cent. of the total power. This

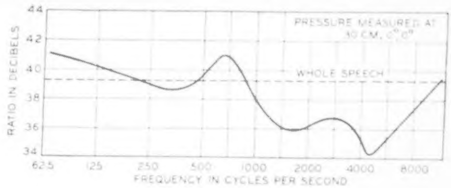

FIG. 6. AVERAGE SPEECH POWER
RATIO OF POWER IN TOTAL FIELD TO THE POWER PER SQUARE CENTIMETER AT A SINGLE POINT.

curve shows that for the male voice tested, 80% of the total speech power is in the frequency band from 250 to 1000 cycles; that 96% is in the band from 125 to 2000, and that only 0.4% is above 4000 cycles.

Previous to these tests, a common method of estimating total speech power was to assume that the pressure directly in front of the speaker was constant over a hemisphere. A similar calculation made from data taken on these tests gives a result 2 db lower than that obtained from the more complete integration. Although the total speech power will vary with the person talking, this difference for the two methods of calculation should remain constant, and so it is safe to assume that calculations made on the basis of a single reading in front of the speaker have been about 2 db too low.

This ratio of total speech power to the power per square cm at one point was calculated for all the frequency bands as well as for whole speech. A curve expressing this ratio for a point 30 cm directly in front of the speaker's mouth is given in Figure 6. Such a curve may be drawn for any of the points at which measurements were made, but the shape of the curve would vary with the point taken. With such curves available, the total speech power may be determined from measurements made at a single point.

JEWISH PRODUCTION OF AMERICAN LEADERS

By Dr. MAPHEUS SMITH and RASHEY B. MOTON
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MANY of the most eminent men of history have been of Jewish extraction, among whom the names of Spinoza, Disraeli, Ferdinand Lassalle, Heine, Ricardo, Marx, Moses Mendelssohn, Felix Mendelssohn and Jacques Offenbach are among the most prominent. Of contemporary eminent men of science and philosophy Einstein, Bergson, Ehrlich and Freud take the front rank. In the theater such actresses and actors as Rachel, Bernhardt and Muni, and such producers as Belasco and Reinhardt immediately come to mind as bearers of a great tradition. Most of the current masters of the violin are Jews. A number of leaders in law and government also represent the group, including Secretary of the Treasury Morgenthau, Supreme Court Justice Frankfurter and the recent Justices, Cardozo and Brandeis. In philanthropy the names of Guggenheim and Rosenwald are among the most notable. And such Jewish families as the Rothschilds in finance, the Flexners in education and medicine and the Lévys and Helévys in France, famous in a variety of fields, demonstrate that Jews have talent in all fields of endeavor. Several hundred other eminent persons might be named, if both historical and contemporary groups[1] are included.

Long ago Lombroso made a strong case for the Jews as a "race" of genius, saying the European Jew is superior to the African and Asiatic members of the group.[2] Sorokin reported Jews to be well represented among American millionaires,[3] and Davis found that Jews were three times as numerous among Russian communist leaders as their proportion in the total population would lead one to expect.[4] Cattell mentions the intellectual prominence of the Jewish group, seven of the leading one hundred American scientists in 1903 and 1906 being Jews;[5] and Roback reminds us that fifteen of the Nobel prize winners up to 1927 were Jews or of Jewish descent.[6] And according to Joseph Jacobs's estimates, Jews, during the century from 1785 to 1885, surpassed Englishmen in per capita production of "illustrious" and "eminent" men, but were surpassed in production of "distinguished" persons.[7] It is therefore clear that in the past and present Jews have not only made many outstanding contributions, but their production of leaders has always been proportionate to or above what should be expected when we consider their numbers in the total population.

Throughout the years since prominent people have been studied as a class, there has been no attempt to determine the contribution of American Jews to the

[1] A. A. Roback, "Jewish Influence on Modern Thought," Cambridge, Massachusetts, 1929, for a discussion of eminent Jews.

[2] Cesare Lombroso, "The Man of Genius," pp. 133–136. London, 1891.

[3] P. A. Sorokin, *Jour. Social Forces*, 3: 627–640, 1925.

[4] Jerome Davis, "A Study of One Hundred and Sixty-three Communist Leaders," Publications of the American Sociological Society, 24, 45, 1930.

[5] J. M. Cattell, editor, "American Men of Science," pp. 783–784, 1921. Out of 738 families mentioned specifically thirteen were Jewish on both sides and one was Jewish on one side.

[6] *Op. cit.*, p. 219.

[7] Joseph Jacobs, *Jour. Anthrop. Inst. of Great Britain and Ireland*, 1886, 15, 251–279. Galton's procedures for selecting eminent persons were employed.

total list of eminent personages in the United States. But some data on this subject, obtained from "Who's Who in America," 1938–1939, and "Who's Who in American Jewry," 1938–1939, are for the first time available. A check of the entire "Who's Who in America" list was made against the entries in "Who's Who in American Jewry," a total of 1,112 names being found in both lists. An additional 20 names not found in "Who's Who in American Jewry" reported Jewish religious affiliation in "Who's Who in America," making a total of 1,132 Jews included in the larger list. This total, which is to be considered a minimum figure, is equivalent to one "Who's Who in America" Jew to each 4,212 Jews in the population of the United States in 1938.[8] Since the corresponding ratio between the total names listed in "Who's Who in America" and the estimated United States population of 1938 was 4,140,[9] Jews are approximately as well represented as non-Jews.[10]

Although they are represented up to expectancy in the "Who's Who in America" group, the Jewish contribution of prominent Americans is not as high as should be expected of a group having their opportunities. In view of the fact that Jews in the United States have been and are almost exclusively urban residents (99.1 per cent. of all members of Jewish congregations in 1936[11]), and the fact that persons born in cities or living in cities have more chances for eminence than those born in or residing in rural areas,[12] Jews should be expected to surpass the average of the United States population in contributing to the list of eminent personages. The reason they fail is that they must overcome a variety of serious handicaps. One which they face in common with other large population groups is the large proportion of them who are foreign born. In general the foreign-born population has less than half as much chance for high social recognition as the native-born population.[13] The Jews have overcome this handicap and have made a much better showing than many other large immigrant groups which have taken up an almost exclusively urban residence, for example, Italians, Poles and Greeks,[14] but they have not accomplished more in this respect than some other immigrant groups which were forced to learn a new language, for example, French, Dutch and Icelanders.

Other handicaps that have had to be overcome are the poverty of a large part of the Jewish group; the strong isolationist tendencies characteristic of persecuted minority peoples, in this case deriving from their history in other countries; differences in social status between the German groups who arrived early and the Russian groups which came later; and the various forms of discrimination all have faced. Discrimination has been a special obstacle in some fields, particularly those which would involve personal relationships of social or administrative superiority on the part of

[8] Based on an estimated 4,768,352 Jews in the United States in 1938. The estimate was derived from the 1936 religious census report of Jews (4,641,184 persons, "Census of Religious Bodies, 1936," *Bulletin* No. 72, "Jewish Congregations," Washington, 1940, p. 2) corrected by the addition of 127,168 persons who were added, on the assumption that the 1926–1936 percentage rate of increase among United States Jews was continued for an additional two years.

[9] The 1938 mid-year population estimate of the Census Bureau was employed.

[10] Actually the Jews are slightly below expectancy among the "Who's Who" names, but there may be sufficient error in the reports to bring the group up to a proportion among the eminent equivalent to that of its population in the country.

[11] "Jewish Congregations," p. 1.

[12] See the summary in P. A. Sorokin, C. C. Zimmerman and C. J. Galpin, "A Systematic Source Book in Rural Sociology," Volume III, pp. 296–304, Minneapolis, 1932.

[13] Mapheus Smith, *Sociology and Social Research*, 20: 424–426, Table I, 1936.

[14] *Ibid.*

Jews over people of the older American stocks. The group has thus been handicapped in teaching, in government and in the military services, all of which provide comparatively numerous opportunities for the highest recognition.

Attempts to account for the ability of the Jews to overcome their various handicaps will fail unless we go beyond their urban opportunities, which are to some extent cancelled out by the poverty of the group. It is necessary to discover other and more positive considerations, if their contribution to American leadership is to be adequately understood. One of the most important questions is that of Jewish intellectual ability. Data clearly establish the slight intellectual superiority of Jews over non-Jews in cities in the United States, as well as in London. Studies of several thousand children in London disclosed an IQ superiority at each age from 8 to 13 years.[15] In eight studies made in the United States and summarized by Pintner in 1931 four showed superiority for the Jews, three for the non-Jews and in one the two groups were equal.[16] In addition, Jewish students have been found to score higher than non-Jews in the Thorndike Intelligence Test, in college marks and in the Moss Social Intelligence Test.[17]

The evidence on the intellectual variability of the Jews is also indicative of superiority. Terman found that children with at least part Jewish blood were twice as numerous in his group of superior children as Jews were in the population of the localities covered by the study,[18] and they held their own in the follow-up studies, although the total group of children declined slightly in IQ.[19] Hollingworth also says that Jewish children are often very superior in intellectual status. Indeed, three of nineteen cases of children testing above 180 IQ were descended from Jewish families on both sides,[20] which means that a larger proportion of very intelligent children are Jews than would be expected on the basis of the size of the Jewish population. The exact superiority is impossible to determine, however, owing to the fact that the Jews, being an urban people, are more likely to be discovered by mental testers. The small number of cases makes it very unsafe to generalize further than to say this evidence is consistent with all the other data. Both in average intellectual status and in variability in the superior intellectual range the Jews are equal or superior to the mass of the non-Jews.

Jews are more susceptible to mild insanity than most other groups. This has been mentioned by Lombroso and others,[21] and, when considered in relationship to general ability, is in line with the theory of biological variations as the

[15] M. Davies and A. G. Hughes, *British Jour. Psychol*, 18: 134–146, 1927; and A. G. Hughes, *Eugenics Review*, 20: 89–94, 1928.

[16] Rudolf Pintner, "Intelligence Testing," pp. 453–454, second edition, New York, 1931. More than 2,500 cases were included in these studies.

[17] H. E. Garrett, *Personnel Jour.*, 7: 341–348, 1929.

[18] L. M. Terman, "Mental and Physical Traits of a Thousand Gifted Children," pp. 55–56, Stanford University, 1926. Also see P. A. Witty, Yearbook of the National Society for the Study of Education, 39, Part II, 401–409, 1940.

[19] B. S. Burks, D. Jensen and L. M. Terman, "The Promise of Youth," p. 54, Stanford University, 1930. Also see L. M. Terman and M. Oden, "Correlates of Adult Achievement, in the California Gifted Group," Yearbook of the National Society for the Study of Education, 39, Part I, 81, 1940, for the statement that a larger proportion of Jews were in the highest 25 per cent. of the gifted group than in the lowest one fourth.

[20] L. S. Hollingworth, "Gifted Children," pp. 70–71 and Chapter IX. New York, 1927.

[21] Lombroso, *op. cit.*, pp. 136–137; J. Slawson and M. Moss, *Jewish Social Service Quarterly*, 12: 343–350, 1936.

explanation of both phenomena.[22] Jews are also well adapted emotionally to achievement[23] and are very aggressive in many ways. The persecution of the group, their continued intermarriage, and the possibilities of social selection also can be fitted into a hereditary interpretation of their superior production of eminent personages.

On the other hand, it must be strongly emphasized that mental ability and temperamental traits do not bear a perfect relationship to achievement nor achievement to social recognition. The social factors of tradition, early training and continued focus on success and leadership must be accorded great weight in the total explanation of the Jewish contributions to eminence. For example, there is a powerful tradition of striving for achievement and a powerful stimulus to success. This is reflected in all parts of the Jewish family and community, as the following description indicates:

> No Jewish boy was allowed to grow up without at least a rudimentary knowledge of Hebrew. The scantiest income had to be divided so as to provide for the boys' tuition. To leave a boy without a teacher was a disgrace upon the whole family, to the remotest relative. . . .
>
> My brother was five years old when he entered on his studies. . . . After a boy entered heder, he was the hero of the family. He was served before the other children at table, and nothing was too good for him. If the family were very poor, all the girls might go barefoot, but the heder boy must have shoes; he must have a plate of hot soup, though the others ate dry bread. . . . It was not much to be a girl, you see. Girls could not be scholars and rabbonim.[24]

In the case of the Jews there is also an element of group conflict arising from prejudice and oppression, on the one hand, and pride in group achievement, on the other hand. And also to be considered is the factor of high intensity of social contact and interaction in the urban habitat. The various social conditions mentioned suggest that a large part of the group's production of eminent men is due to non-hereditary psychological and social factors.

Occupations of Prominent Jews

The occupational distribution of prominent Jews differs in important respects from that of the total "Who's Who in America" group (Table I). Jews surpass non-Jews in the theater, painting and sculpture, law, music and social science. They are at a disadvantage in agriculture, architecture, education, engineering, library and museum leadership, military affairs, natural science, political and civic leadership and religion.

TABLE I

Occupational Distribution of Prominent American Jews, 1938–1939

Vocation	Jews		Non-Jews	
	Number	Percentage	Number	Percentage
Actors, producers	37	3.3	189	.6
Agriculturists, foresters, etc.	0	0.0	185	.6
Architects	7	.6	253	.8
Artists (painters, sculptors)	50	4.4	893	2.8
Authors	115	10.2	2,771	8.8
Bankers, financiers	50	4.4	1,021	3.3
Business proprietors and executives	122	10.8	2,507	8.0
Doctors of medicine	134	11.8	2,166	6.9
Educators	101	8.9	5,373	17.1
Engineers, inventors	24	2.1	1,172	3.7
Journalism, publishing	66	5.8	1,837	5.8
Lawyers, jurists	165	14.6	3,552	11.3
Librarians, curators	5	.4	266	.8
Military leaders	0	0.0	540	1.7
Miscellaneous	4	.4	114	.4
Musicians	65	5.7	592	1.9
Natural science	44	3.9	1,709	5.4
Public officials, civic leaders, social workers, etc.	54	4.8	2,467	7.9
Religious leaders	60	5.3	3,299	10.5
Social scientists, statisticians	29	2.6	548	1.7
Total	1,132	100.0	31,454	100.0

These conclusions are in most respects in agreement with those of Jacobs, whose study a half century ago was based on historically important personages of Europe covering the period 1785–1885 (Table II). Lack of agreement between

[22] Havelock Ellis, "Man and Woman," pp. 450–457. Boston, 1929.

[23] *Cf.* L. S. Hollingworth and M. M. Rust, *Jour. Psychol,* 4: 287–293, 1937.

[24] Mary Antin, "The Promised Land," pp. 32–33. Boston, 1912.

TABLE II

JACOBS'S OCCUPATIONAL CLASSIFICATION OF EMINENT EUROPEANS AND JEWS[25]

	Europeans	Jews
Actors	2.1	3.4
Agriculture	.2	0.0
Antiquaries	2.3	2.6
Architects	.6	.6
Artists	4.0	3.4
Authors	31.6	22.3
Divines	13.0	10.5
Engineers	1.3	.9
Engravers	.3	0.0
Lawyers	4.4	4.0
M.D.s	3.1	4.9
Merchants	1.2	4.3
Military	5.6	.6
Miscellaneous	.4	.3
Metaphysics	.2	1.8
Musicians	1.1	7.1
Natural science	2.2	2.5
Naval	1.2	0.0
Philologists	1.3	12.3
Political economy	2.0	2.6
Science	5.1	5.2
Sculptors	1.0	1.2
Sovereigns	2.1	0.0
Statesmen	12.5	8.3
Travelers	2.5	1.2
Total	101.3	100.0

the studies is evident in only five items in which direct comparison is possible, while there was agreement between the studies in the theater, agriculture, religion, engineering, medicine, music, business, military affairs, social science and political and civic leadership. In Jacobs's study Jews were at a disadvantage in painting and sculpture, authorship and law, at an advantage in natural science, and neither at a disadvantage nor an advantage in architecture.

As with total group differences in achievement, hereditarian interpretations are frequently made of differences between groups in kinds of achievements. Thus, it is possible to argue that Jews possess superior natural ability in the arts, on the suppositions that talent is associated with interest and other motivating forces and that a combination of talent and motivation inevitably produces proportionate achievement and fame. However, each of the suppositions in this chain of inference is subject to question. It is not certain that population groups differ in musical or other talents, nor is it certain that talent, unaffected by other facts, produces motivation to achievement. Furthermore, it is well known that minority groups, prevented by the traditions and active pressures of the majority group in a social order from equal participation in all vocational fields, tend to find expression for their abilities in the arts. As a result ordinary artistic talents may be expected in time to receive unusually vigorous expression and to give the impression of a high level of hereditary artistic talent in the group.

What is needed before a correct evaluation of the differential vocational achievements of groups can be made with assurance is information on the opportunities for achievement and recognition in various fields. A major statistic required is the total occupational distribution of various population groups, in this case, of Jews and non-Jews in the United States. We do not know whether Jews, in proportion to their appearance in those occupations, are superior in the arts or whether they seem to stand out because so much larger a proportion of the total employed in the arts in the United States are from the Jewish group. Even in the absence of such data, however, it is possible to suggest some hypotheses to account for the vocational differences revealed in Table I, although these hypotheses can not be fully evaluated until more information is available on special abilities, interests, discrimination, occupational data and avocational activities.

The traditional element in Jewish artistic, banking and business accomplishments is particularly large. In the theater and in music there has for a long time been a strong Jewish emphasis, and these have been extended with the development of motion pictures and. radio.

[25] Jacobs, *op. cit.*, p. 363. The data from which these figures were obtained were not presented, and it is therefore impossible to correct the figures for Europeans to take care of the excess in the percentages.

From prominence in the theater and music the spread of interest and leadership to other arts is readily understood. Literature offers an opportunity for minority groups, because of the generally indirect relationships between the author and the public. Leadership in banking and business is to some extent explained by Jewish leadership in these fields during ancient and medieval times, and the traditional extension to the present. It is also likely that small opportunities for Jews in some fields, such as the higher political positions, the colleges and universities, libraries and museums and military affairs have caused them to concentrate in such learned professions as law and medicine, as well as in the arts and business.

Few American Jews live in rural districts, and practically no large-scale agricultural operators are found among them. The disadvantage of the Jews in such practical pursuits as architecture and engineering is not clearly understood, but probably is explained by lack of interest in such professions, rather than by discrimination. The same argument applies to some extent to the natural sciences, in which Jews showed up to such great advantage in Jacobs's study of Europeans. In political and civic life and in military affairs we can see the effects of prejudice and discrimination directed toward a minority group predominantly made up of recent immigrants, living in the centers having strongest foreign ties. The Jewish American is also to some extent discriminated against in education[26] and library and museum leadership. The group's disadvantage in religious leadership is probably explained by the ratio of religious leaders to all people among the Jewish and non-Jewish populations, some of which may be due to the concentration of the Jews in urban areas where there may be relatively few rabbis to the total people in the community.

It should be emphasized again that our knowledge of the facts associated with the listing of persons as prominent are too limited to certify the factors responsible for the general and occupational contributions of the Jews to a group of notable Americans. The only thing reasonably certain is that the explanation is complex. No single factor explains any of the rates of production. And we do not even know that social or environmental factors are adequate to the exclusion of hereditary ones. But it seems clear that major weight should not be given to heredity, since such matters as interest, discrimination, opportunity and tradition seem to be of most significance.

The facts reviewed in this paper are of particular importance at this time, because of the tendency for each minority group to be given special attention when a critical situation faces a nation. Generally some one minority group will be singled out as a special object of hatred or overt violence, being blamed for conditions for which it is in no way responsible. Sometimes this is done deliberately by demagogic leaders, but such an interpretation frequently is borrowed by a leader from ordinary people who have for a long time held illogical prejudices against a group. Because of preconceptions many Americans have reacted antagonistically toward the Jews. But the data presented above offer no support for the idea that the Jews dominate America out of proportion to their numbers. Jews do not appear to an overwhelming extent as leaders in any of the vocational fields and they do not come up to expectations in a number of occupations. Their appearance in finance, law and business may be expected to call unfavorable attention to them, but there are no grounds in any of the data for special emphasis on the quantity or quality of the group's accomplish-

[26] *Cf.* Ludwig Lewisohn, "Upstream," for a vivid example of such discrimination. New York, 1922.

ments. Instead, it should be kept in mind that their contribution is in every case as much an American contribution as those of other Americans. We have no reason to suppose that this group has any more pride in its accomplishments than has any other religious, or any ethnic or language, component of the American population, or that it is more interested in having itself singled out for comment than is true of any other part of the population. Our interest in the contributions of any part of the American population should be purely of historical and academic interest, especially in view of the fact that all religious minorities seem to be equally loyal to the principles on which the nation is founded; and the same is true of all national minorities, except those attached to some aggressive international political and military movement, which, however, in no respect applies to the Jews. Indeed, there is reason to believe that the assimilation of the Jews in this country will proceed until studies of the sort reviewed here will cease to have even an academic interest, if the rest of the American people put no emphasis on religious, nationality and culture differences and cease to discriminate against the Jews.

FATS AND OILS

NOT counting petroleum oil and essential oils used in perfumes, there are about 30 fats and oils which form an important part of our peacetime life and are grim necessities in war. War in the Pacific has jeopardized two thirds of the 15 per cent. of these fats and oils we normally import.

Fats and oils are necessary for food, for soap, for paints, varnishes, linoleum and printers' ink, for industrial lubricants, and in the manufacture of metals, textiles, leather goods and glycerine. In times of peace, glycerine, required in the making of nitroglycerine and other explosives, is a by-product of soap-making, but in time of war soap rather becomes a by-product of glycerine manufacture.

Edible fats are highly important foods in wartime because their outstanding caloric value makes them especially needful for the armed forces and for civilians working longer hours and under increased strain. The paint and varnish oils are used increasingly for the protective coating of ships, tanks, guns, planes, cantonments, and so on. Special lubricants are required more than usual for high-speed motors and metal-turning lathes.

In 1940–41 we imported 1.6 billion pounds of fats and oils, including the oil contained in oilseeds, and more than half of these products originated in the Pacific area. The principal items imported from this area were coconut oil and copra, mostly from the Philippines, and palm oil, from the Netherlands Indies and Malaya. Imports of perilla and of tung oils also originated in the Pacific; Japan controls the supplies of the former, while the latter is a Chinese product. Alternative sources of supply for coconut oil and copra were the Netherlands East Indies, and various South Pacific Islands, as well as East Africa, whence we may still derive some. In the past we have also obtained considerable quantities of palm oil from West Africa.

Substitutes for coconut oil are available in the form of babassu and other palm-kernel oils contained in the nuts of certain varieties of palm trees found in great profusion in tropical Latin America. But transport, labor and equipment shortages preclude any rapid expansion of imports of palm-nut kernels to the United States. Fairly large quantities of palm-kernels are available in West Africa. Brazilian oiticica oil and dehydrated castor oil, derived largely from Brazilian castor beans, are already being used to supplement supplies of tung oil and perilla oil in the United States.—*United States Department of Agriculture.*

THE WHALE SHARK IN THE PHILIPPINES

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THROUGHOUT the ages sharks have been of well-nigh universal interest. Lacking the gorgeous colors or flower-life brilliance of coral reef fishes, or the superb symmetry and graceful gyrations of others, they have yet irresistibly compelled the attention of man. Most sharks are dull in color, uniformly gray, bluish or brown, only a small number being decorated or colored in such a way as to attract attention.

While a few sharks, such as the weird hammer-heads, have excited astonishment by their singular physiognomy, other characteristics have been the means of causing mankind to observe and speculate about them. The qualities that have aroused awe and curiosity are uncommon size, speed, great greed and dangerous ferocity. It is the combination of all these in the popular mind that has made the name shark a symbol for all that is fierce, rapacious and ruthless to millions who have never seen one.

It is not of man-eating sharks nor of the living fossils that range the depths nor yet of the pygmy phosphorescent sharks less than a foot long that these observations are recorded. Instead, the subject is a harmless blundering giant, the largest of all living fishes, the titanic whale shark, *Rhineodon typus* Andrew Smith.

One hundred fourteen years ago, in April, 1828, to be exact, a large shark was seen swimming aimlessly at the surface in Table Bay, Cape of Good Hope, South Africa. It was unlike anything known to the local fishermen, and its color was different from that of any shark occurring in those waters. It was easily harpooned and towed ashore. Here it was turned over to Dr. Andrew Smith, an army surgeon. He recognized it at once as something hitherto unknown, and published a description of it. Some years later he published the first, and one of the very best figures ever made of it.

However, long before Dr. Smith's scientific account, Captain H. Piddington, the English commander of a small Spanish brig, saw a *chacon,* or whale shark, in December, 1816, while his vessel was lying at anchor in Mariveles Bay, a small haven near the entrance of Manila Bay. He did not publish his observations until 1835, when his article entitled, "Notice of an Extraordinary Fish," appeared in the *Journal of the Asiatic Society of Bengal.* The *chacon* passed under his ship, moving slowly as is the wont of the whale shark, and he had a good view of it. He estimated its length as "not less than 70 or 80 feet." He was told that formerly there had been two of the monsters, but that about 1800 one was driven ashore, where it died. Captain Piddington's article has been reproduced in full by my friend and scientific colleague, Dr. E. W. Gudger, internationally known ichthyologist of the American Museum of Natural History. Captain Piddington's account is therefore the first authentic record of the occurrence of the whale shark in the Philippines.

In his article Captain Piddington added "a vague notice of monstrous spotted fish, which are known to the Moluccas." The Malay fishermen described them to him as "spotted, as large as a whale and highly destructive to nets, which they instantly take up as soon as they see the fish, if they can get time to do so; for it is known to destroy boats, and whole lines of nets and fishing

stakes, if it once became entangled amongst them."

Continuing his narrative, Piddington says, "I had the same account corroborated in the Sooloo Islands, both by Malay and Chinese fishermen; as also at Zebu, in the Philippine Islands."

There have been no Chinese fishermen in the Sulu Sea for many years, except perhaps a few at the entrance to Sandakan Bay, British North Borneo. By his Malay fishermen in the Sulu Islands, Piddington evidently meant the bold and hardy Samals, erstwhile pirates and always excellent seamen and fishermen. Their knowledge of the fishes of the Sulu and Celebes Seas is both extensive and accurate. We may therefore accept this statement as evidence that the whale shark was well known in the Sulu Sea more than a hundred years ago. What he was told at Cebu agres exactly with our present knowledge of the distribution of the whale shark in Philippine waters.

The whale shark has several characteristics that strikingly differentiate it from all other sharks, large or small. It is usually reddish or grayish brown, or mouse color, with large white or yellowish circular spots the size of a silver dollar or larger, which occur all over the body and fins, except on the under side. On the head the spots are much smaller and more crowded; on the body there are also vertical white or yellowish lines or stripes, running from the back to the belly, which connect the circular spots. These lines may be continuous, but are more often interrupted, thus forming a series of short vertical stripes.

Another very marked characteristic is the presence of two longitudinal keels or ridges on each side, beginning above the fifth gill slit, the upper one soon dividing and terminating near or under the second dorsal fin. The lower one continues on back in a more or less wavy manner until it is lost in the strong keel on either side of the tail. The huge head is very blunt, broad and depressed, with a perfectly enormous mouth, which is at the front instead of being beneath and far behind the snout, as in most sharks.

The immensely wide mouth has a band of about three hundred rows of minute teeth in each jaw, each row containing from fourteen to thirty teeth. The number of teeth varies from about 5,000 to 9,000. The whale shark feeds on very small fish, crustacea, mollusca, medusae and various other pelagic organisms occurring in vast schools at or near the surface of the sea. It feeds in the same manner as ordinary whales do, that is, by swimming slowly with wide-open mouth through schools of the organisms which form its food. After the mouth is filled with sea water and the mass of small animals, it is closed and the water is expelled through the gill openings, which are provided with a fringe of mesh-work that serve as a strain.

The whale shark is one of the mildest and most inoffensive of all large animals. In spite of its enormous size and monstrous strength, it never attacks anything larger than the small animals on which it feeds. When harpooned or shot it makes no particular attempt to escape, nor does it use its great strength to wreck the boat of its enemies. The only exceptions noted during more than fifty years are those recorded by Wright, the naturalist, who observed the shark at the Seychelles. According to him it sometimes rubs itself against a pirogue (dug-out canoe) and consequently upsets it, but never attacks any one. He also states that sometimes when a whale shark is harpooned it dives with very great rapidity until the rope is all out, and then keeps on downward until the boat is carried under before the crew has time to escape.

Accordingly, the sperm whale fishermen were in great dread of mistakenly harpooning a whale shark, instead of a

whale. The latter must return to the surface after a time to breathe, but the fish could go to a vast depth and remain there. However, the statements about carrying boats under water were hearsay, as Wright never saw anything of the kind himself. With the exception of Piddington's original account, all other statements made for over a century, by actual observers, were unanimous in saying that a whale shark when harpooned swims slowly away at a speed of two miles an hour or little more, or else circles aimlessly about at the same slow speed. When Piddington's boatswain and four companions harpooned the "chacon" it towed them "at such a fearful rate out to sea that they were glad to cut from it immediately."

In the last chapter of Zane Grey's "Tales of Fishing Virgin Seas," published in 1925, there is a description of an encounter with a whale shark over fifty feet long off Cape San Lucas, Lower California, where whale sharks are common. The great fish was harpooned and fought from noon till after sunset. During that time it sounded five times, going down to 1,200 feet the fifth time. Finally it sounded for the sixth time. At 1,500 feet the last ball of rope was added and the fish had to be released or it would have taken the boat down, too. There is no question, therefore, that the whale shark does, at times, free itself by going far below.

At intervals during the seventy-two years between 1828 and 1900, various observers reported the whale shark on the coast of Ceylon, in the Gulf of California, around the Seychelles (a group of small islands in the Indian Ocean) near Callao, Peru, in the Bay of Panama, and on the south coast of New Guinea.

With the dawn of the present century, whale sharks began to be noticed in many localities. Such diverse regions as Japan, Celebes, in the Dutch East Indies, Florida, the Hugli River in India, Java, the Bonin Islands, the Strait of Bab-el-Mandeb, the Gulf of Guinea, and many other localities distributed throughout the Pacific, Indian and Atlantic Oceans, were added in rapid succession. Beginning in 1910, the record of whale sharks in Philippine waters is greater than that of any other region, but first a few words concerning the method of their capture.

One of the most important means of fishing throughout Malayan countries is that of constructing fish corrals of one sort or another at strategic points. They are of all sizes, from tiny affairs only large enough to hold a dozen fish or so weighing a pound or two apiece, to gigantic complicated affairs that in one night, or at a favorable turn of the tide, may catch three or four thousand fish, weighing an average of five or six pounds apiece.

These corrals are placed at all depths between those that are exposed on flats at low tide to those that stand where the water is permanently forty-five or fifty feet deep. They may be flimsy fences of reeds and bamboo, costing only the necessary labor, or they may be huge solidly built structures of great hardwood logs, rattan and bamboo, tied together by roots that resist the action of salt water, which cost several thousand dollars.

In the outlet of every lowland lake, at every river mouth and on a coastal sheltered beach or reef anywhere, one sees an array of fish corrals. As the tides change and currents shift, as the monsoon winds blow now this way and now that, the movements of fishes, and indeed of all free natant life, are likewise altered. Into the corrals accordingly there comes a vast variety of fishes and other organisms, and often a great number of a single species when a migrating school is captured, as occurs when a corral is placed across a reef channel regularly used in migrations. Follow-

ing their food of squid, floating mollusca, schools of crustacea or of small fishes frequenting shallow water or perhaps merely traveling with the current, such large animals as blackfish, porpoise, small whales, dugong, saw-fish and whale sharks are led into the pounds of fish corrals. There they remain, except when a gam of blackfish or a school of porpoise is captured. When they once realize that they are imprisoned, they burst all barriers, leaving behind only a wrecked corral.

If one remembers that there are more than 7,000 islands in the Philippines, ranging in size from mere rocks to the size of Ohio, with more than 400 permanently inhabited, it is evident that the Islands have an enormous coast-line. It is on this coast-line that most of the 16,000,000 inhabitants live. With fish corrals scattered along most coasts, there are in the aggregate thousands of fish corrals in operation for at least a large part of every year. With this great number of fish corrals, the chances for capturing strays and rarities of many species are immeasurably increased.

To return to the first capture in 1910, in August a giant shark was discovered in a fish corral at a barrio or village of the municipality of Bacolod, Occidental Negros. After the tide went out, the great fish was partially stranded. It was then killed and dragged by an excited crowd more than two kilometers inland, to Bacolod itself. Here a local photographer took a picture of the shark in the midst of the crowd that was sent to the *Philippine Free Press,* which published it in the September 10, 1910, issue.

During 1914, two whale sharks were captured in the Philippines, and a school of them was observed about that time, but published notices were not made till afterward. Most of the information relating to that period has been obtained from Captain William M. Steirnagle, who was in command of the Coast and Geodetic ship, "Romblon" from 1912 to 1915. During this period surveys were being made of the coasts and reefs of the Philippines. Several years after returning to the States, Captain Steirnagle called on Dr. Gudger and told him of observing whale sharks in the Philippines and of frequently seeing as many as fifty whale sharks in a school. He gave Dr. Gudger several small pictures, one of which shows the exposed head of a shark which is readily recognized as a whale shark by its spots and by the shape of the head.

In *Science,* Vol. 41, p. 463, 1915, Dr. David Starr Jordan published a note concerning a photograph he had received from a former student of a whale shark captured at Cebu, where the former Stanford man had seen it. Since the ex-student lived in Zamboanga, the fish has later been erroneously recorded as having been taken at that place.

In September, 1914, another whale shark, a young one eighteen feet long, was caught in a fish corral at Argao, Cebu, a town on the east coast about forty miles south of the city. An excellent photograph of it was taken by an American friend of mine, who later gave me a copy. This shark was not put on record until January, 1925, when I published an account of the whale shark in the *Philippine Journal of Science,* Vol. 26, pp. 116–117.

While I was in Zamboanga in 1920, an American friend gave me a copy of a picture he had taken of a whale shark caught a few months before in a fish trap near Zamboanga. Soon I sent the picture to Dr. David Starr Jordan, who acknowledged its receipt but never published anything about it.

Early in 1921 while overhauling and naming the fish collection in the museum of Santo Tomas University, Manila, I found on display a stuffed and unnamed whale shark. It was another baby fish, only thirteen feet and nine inches long,

next to the smallest specimen on record. The taxidermist and curator was an elderly Filipino who had spent practically all his life in the museum, his father having been taxidermist before him. He told me that the whale shark was taken in 1840, in Manila Bay off Navotas, by fishermen of that town. He further stated that his father, a boy of eighteen at the time, had helped prepare the skin, but did not remember anything about the manner of its capture. Although the old skin was badly battered and showed hard usage, it had evidently been mounted while in perfect condition, but time and reckless students had done their worst. When the university was moved to the northeastern part of Manila the shark disappeared. In my 1925 article, previously cited, I mentioned this 1840 Navotas specimen.

In January, 1925, while I was absent in Mindanao, word came to the Bureau of Science that a whale had been caught in a fish corral at Salinas, a village near Cavite, the well-known naval station on Manila Bay. Several of the staff went to Salinas and found a whale shark that had blundered into a fish corral at high tide and which was stranded at low tide. It died the next day, at which time pictures were taken by the Bureau photographer, and it was measured. It was thirty-three feet in length, the largest whale shark ever handled in the Philippines by scientific men, but the other measurements made are not now accessible. The owners employed a Manila taxidermist who prepared it for exhibition and for a year or two it was shown at carnivals and fairs.

January, 1925, was a good month for whale sharks. My first assistant, Mr. H. R. Montalban, leaving Lanao about the tenth of the month for Manila, stopped at Dapitan, a town at the northwest angle of Mindanao. From the deck of the steamer he saw a whale shark swimming slowly at the surface of the sea and obtained a very good view of the characteristic spots and shape of the head. A number of other passengers saw the shark and several fired shots at it from revolvers.

The tenth recorded specimen, reported to be nineteen feet long, was taken in 1929 at the barrio of Garat near Libagon, a town on the east side of Sogod Bay at the south end of Leyte. It was reported to be nineteen feet long. The photograph taken of it shows admirably the characteristic wide depressed truncated head.

In September of the same year another whale shark wandered into a fish corral at Cebu, the capital of Cebu. This fish was approximately sixteen feet, five inches long. Again a young *Rhineodon typus* swam into a fish corral, this time at the village of San Vicente, a barrio of Malitbog, a town on the west side of Sogod Bay, Leyte. Malitbog is about ten miles southwest of Libagon on the opposite side of the bay, where a whale shark had been taken six months before. In February the whale shark was hauled out on the beach and a fair picture, taken by a local photographer, indicates that the fish was more than twenty feet long.

Two whale sharks were seen in 1931, the first in February by Mr. A. D. Lee, at that time in charge of fishing operation for the Philippine Packing Corporation in Iligan Bay on the north coast of Mindanao; the second, three months later, was caught in a fish corral at Maasin, a municipality on the southwest coast of Leyte. No data are available as to its length, but it was apparently about 20 feet long judging from a photograph of the crowd of men and boys around it.

On the fourth of August, 1931, I saw a whale shark on the coast of Darvel Bay, British North Borneo, and later (April 15, 1932) published a note about it in *Science*. This record might without much stretching be reckoned in

Philippine waters, since the locality is only about 15 miles from the north end of Sibutu, an island of the Sulu Archipelago.

On January 7, 1932, Navotas fishermen, finding a young whale shark in a fish corral, hauled it out, and pictures of it lying on the beach were taken with a small camera. It was apparently between eighteen and twenty feet in length. In March still another small whale shark entered a fish trap, this time at Aplaya, a barrio in the municipality of Bauan, Batangas Province, Luzon. Bauan is directly south of Manila, on Batangas Bay, an indentation of Verde Passage. This specimen was only seventeen feet and four inches in length.

Later in the year Mr. A. D. Lee again reported seeing many whale sharks. On the first of June, while cruising in Dapitan Bay just southwest of Tagolo Point at the northwest corner of Mindanao, he encountered a school containing fifteen or more whale sharks, ranging in length from twenty to more than fifty feet. Mr. Lee reported that the vessel was fifty feet long and that some of the sharks alongside were even longer. He actually counted fifteen fish, after which he was too busy steering away from the school lest one of the fish come up under the launch and capsize it. On three separate occasions Mr. Lee and his companions saw a school of whale sharks, probably the same school each time, in the region about Tagolo Point.

In February, 1933, a young whale shark was caught in a fish corral at San Jose, Antique Province, Panay. The local fishermen, thinking that it was a man-eater, were afraid to attack it. After several days, Captain Flores, of the local constabulary, went to the corral and with his service rifle wounded the shark, which then broke through the corral. It was pursued in a boat and finally killed. When dragged out on the playa, it was found to be about eighteen feet long. An account of the capture and killing of this whale shark was published in the *Philippine Free Press* on February 25, 1933.

On an afternoon in April, 1934, Dr. Paul Smith, of the United States Quarantine Service at Manila, was fishing near Mariveles, a small town on a landlocked harbor at the north entrance to Manila Bay. For some time he observed a large shark which was approached and finally harpooned. After roping it securely, the fish was towed to Manila, where it died the next morning. This whale shark, only thirteen feet in length, is the smallest one captured of which there is any record, so far as I am aware. Its skin was mounted and is now on exhibition in the Bureau of Science Aquarium at the entrance to the walled city of Manila.

Fishermen at Silay, Occidental Negros, reported to Mr. Florencio Talavera, of the Division of Fisheries, Bureau of Science, a large fish which they had captured in a corral. It was clear to Mr. Talavera that this fish, which was about thirty-nine feet long, was a whale shark. This capture was probably made in 1934, but the date is uncertain.

Mr. Wallace Adams, for a time head of the fish and game administration in the Philippines, had records of other captures of whale sharks in the Islands, and had indicated the localities on a small map. When I saw Mr. Adams in San Francisco and discussed with him the occurrence of whale sharks in the Philippines, he was fatally ill and unable to get at his notes. Shortly after, while I was abroad, his death occurred and his miscellaneous papers were apparently destroyed after his library was sold. All these records, including the one at Silay, Occidental Negros, cited above, were between 1930 and 1934.

He told me he had data of the taking of whale sharks at these places: the Gulf of Albay, Albay Province, Luzon;

Maqueda Bay, Samar; the Tapiantana Islands off the south coast of Basilan, a large island near Zamboanga; and Balabac Strait, Balabac. Including the above, we have twenty-four definite records of the occurrence of whale sharks in the Philippines. His untimely death and the destruction of his papers have prevented my getting more precise data.

In addition to these definite records, it is commonly stated by the market vendors of Cebu, Iloilo, Zamboanga, Jolo and Siasi that young whale sharks are brought in from time to time, cut up and sold for food. I am likewise confident that any one familiar with Philippine people and conditions could gather at least twenty more good records in a few months' time. Many times when investigating the distribution of some fish I have obtained the needed information very readily. By descriptions and pencil sketches fishermen would tell me of the various fishes caught or known to them, their habits, mode of capture and local name. Where their descriptions were too vague, their drawings, supplemented by answers to a few judicious questions, would usually enable me to determine the larger fishes known to them with certainty.

The great apparent increase in whale sharks in recent years is not a real increase. The greater number now reported is merely because the recent rapid development of transportation and communication by automobile, bus, steamer, telephone and wireless enables one to hear of events from the multitude of places that only a few years ago were almost totally isolated from the rest of the world. Formerly communication was so infrequent and irregular that even major events like typhoons and destructive earthquakes might not be made known to the outside for at least six months.

The fact that nearly all Philippine whale sharks captured are small, there being but two records of specimens ten meters or more in length, points to two conclusions. First, a breeding ground must be in some locality at no great distance; second, adult whale sharks remain in deep water, rarely venturing into the shallow coastal waters where fish corrals are located.

My eminent colleague, Dr. E. W. Gudger, believes that the Sulu Sea is the chief breeding ground and center of distribution for the whale shark. From long familiarity with the ocean currents about the Philippines, and with the Sulu Sea in particular, I am inclined to doubt this conclusion. The Sulu Sea is a rather small Mediterranean, perhaps 300 by 350 miles if we exclude small island groups and reefs. It is out of the path of main ocean currents, and except for an inlet through the somewhat tortuous straits of Surigao is margined by channels less than five hundred feet deep. The Sibutu Passage has a maximum depth of 3,000 feet, but north of it lies a shallow reef. The Sulu Sea lies in the monsoon belt, and during the northeast monsoon pours a vast stream into the Sea of Celebes, drawing upon the China Sea to maintain its volume of water. During the southwest monsoon the current in the Sibutu Passage is reversed and the Sulu Sea pours its surplus out through Balabac Strait and the channels northward through the Visayas to the China Sea. This in turn creates an eastward current through the Balintang Channel; what effect it has upon Bashi Channel I can not say. Such currents are of much distributional value locally, but are of no import in wide-spread distribution. We may dismiss a sea of seasonal and constantly shifting or reversing currents as one that can not meet the requirements.

The Celebes Sea is a partial Mediterranean of more than twice the area of the Sulu Sea, and is much more influenced by great oceanic currents. It ap-

parently fits the requirements better than the Sulu Sea in all respects, except in the known occurrence of whale sharks. Its great depth and the scant population along its shores would make it improbable that many whale sharks would be captured there.

There is another area which seems to meet all requirements to a far greater degree than either the Celebes or Sulu Seas. This is the region north of New Guinea and partially enclosed by the Philippines, Halmahera and the Pelew Islands. This area receives both the south and the north equatorial currents, and gives rise to the Japan Current, or Kuro Siwo. In the maze of islands between New Guinea and Celebes there is a welter of criss-cross currents into and out of this area, and from it pours a vast volume of water through the Straits of Surigao in the mid-Philippines. This influx of water from the open Pacific and the Sea of Celebes causes an outflow northward through the Visayas during a large part of the year.

From the movements of albacore, tuna, swordfish and sailfish, we infer that they have a breeding ground in the great area above indicated. From it they migrate westward and northward, reaching first the Sulu Islands and Mindanao, then the Visayas, then Luzon as the season advances, and ultimately travel on toward southern Japan. This route of migration seems to be along the equatorial current and its ramifying distributaries, and along the Kuro Siwo and its offshoots entering the Philippines.

Of course, what is true for these great bony fishes may not be true at all for giant selachians, which in all probability produce living young. We have no evidence that sharks of that type have any specific breeding ground, except that of the occurrence of young sharks in a given region. In spite of our lack of positive knowledge of the breeding habits of *Rhineodon typus,* I am of the opinion that the most important breeding ground, or center of life, for western Pacific whale sharks is the region already indicated, lying between New Guinea and the Philippines. It fulfils all the necessary requirements: water of a uniform high temperature, an abundant food supply of pelagic macroplanktonic organisms, constant ocean currents and a vast undisturbed and seldom visited area, remote from steamship routes.

If my suspicion that whale sharks are largely surface feeders is true, the Sulu Sea is much too frequented by men to have very many unobserved schools of whale sharks in its limited area. Commercial steamer routes traverse the Sulu Sea so frequently that it is under observation throughout the year over a large part of its surface. On the unfrequented waters of the New Guinea-Philippine sector of the Pacific, ships are a rarity.

It is evident that whale sharks breed somewhere in the Indian Ocean, having the area about the Seychelles as their center, but probably breeding in other localities as well. Dr. Gudger's explanation of the distribution of the whale shark in the Indian Ocean and in the tropical Atlantic seems to accord perfectly with all the known facts. However, this does not necessarily imply that in any given sea the breeding of whale sharks is confined to any definite and limited area. It merely gives a reasonable explanation of their distribution from their original home somewhere in the East Indian region.

ANCIENT MESOPOTAMIA AND THE BEGINNINGS OF SCIENCE

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LATEST advances in the study of comparative archeology bring out with added emphasis the traditional view that the oldest historic civilizations evolved in Egypt and Mesopotamia. We know also that intellectual and social progress in these two centers kept pace with material developments. The question of relative priority is often injected into discussions on this subject. For the present, at least, such a question is not capable of a satisfactory solution. It is doubtful, moreover, whether an answer can be expected at all, in view of the dynamic character of both civilizations and the consequent rapid diffusion of vital innovations and inventions. There are, however, certain characteristic aspects of progress in the two respective centers which stand out by contrast, and it is to one particular group of such contrasted characteristics that I wish to address myself here. I am referring to progress in science.

The following remarks will embody four main propositions: (1) Available evidence points to Mesopotamia as the oldest known center of scientific observation permanently recorded. (2) Whatever its immediate objectives, this activity comes to include such widely separated fields as education and language study, jurisprudence and the mathematical and natural sciences. (3) The numerous elements in this broad advance are basically interrelated. The common underlying factor to which the initial impetus can be traced is a concept of society whereby the powers of the state are restricted and the rights of the individual receive a corresponding emphasis. (4) It is significant that under the opposed social system of totalitarian Egypt early scientific development differed in scope as well as in degree; while notable in some special fields, such as medicine and engineering, it lacked the breadth and balance manifested in contemporary Mesopotamia.

It should be pointed out at the outset that the specifically scientific content of this account is negligible; furthermore, it is but incidental and wholly derivative. My main objective is to demonstrate that there were elements in the social structure of early Mesopotamia which tended to promote scientific progress. The results happen to constitute the first recorded evidence of scientific performance known to us to-day. To this extent we are justified in touching here upon the beginnings of science, including the natural sciences. But it should be stressed that this presentation is concerned not so much with the results as with the background: a combination of circumstances conducive to concerted scientific activity, rather than the subjects affected by that activity. The background gives us in this instance the essential starting point. It is thus more significant than the immediate achievement.

Our interest, then, will center on a particular cultural stage at which there were at work forces that led to extensive scientific developments; forces which provided the predisposition, so to speak, to these developments. Accordingly, we shall ignore such sporadic achievements of a still more remote age as the invention of the wheel, the introduction of the brick-mold, and perhaps the use of instruments in effecting accurate geo-

metric designs on very early forms of painted pottery. We may have here Mesopotamian inventions which were to play important parts in the eventual progress of engineering, architecture and perhaps geometry. But these inventions represent isolated contributions of discontinuous cultures which scarcely had any immediate bearing on scientific progress. We shall confine ourselves to subjects which had a common origin in a well-defined period and area; which involve from the start habits of observation, classification and analysis; and which enter then and there upon a continuous course of development.

The region to which our inquiry will take us is Lower Mesopotamia, the land of Ancient Sumer. More specifically, it is an area extending southwest from the environs of Babylon, past Uruk—the biblical Erech—and on along the Euphrates to the metropolis of Ur. The time is the middle of the fourth millennium B.C. This is not just a convenient round figure. It will allow a margin of scarcely more than a century or two, and in a total of well over five thousand years this is not a disproportionate margin of error. We are in a position to establish the time with such accuracy because it falls within a well-stratified cultural period marked off sharply by distinctive material remains. Soon thereafter there begin to appear inscribed records which tie up before long with concrete regnal years and provide thus a basis for absolute chronology.

We get our first inscribed documents from a level dated to about 3500 B.C., one of a long series of strata recovered from the remains of ancient Uruk. It is among these documents, written on clay, that we find a few which represent the earliest known scientific records. That similar records of still greater antiquity will ever turn up outside Mesopotamia is highly improbable. All available evidence points to the conclusion that the scientific notations with which we are concerned were compiled in close association with the introduction of writing itself. To be sure, this evidence applies only to the script of Mesopotamia. But writing in all the other ancient centers of civilization is demonstrably later. In Egypt it was introduced some centuries after it had been evolved in Mesopotamia, and its first appearance in India was later still. As for the script of China, there is nothing to indicate that it was earlier than the second millennium B.C. It follows, therefore, that the scientific notations on our earliest Mesopotamian tablets constitute not only the first evidence of scientific activity in Sumer, but represent also the oldest recorded effort of this kind known from anywhere in the world. With this significant fact in mind we shall now turn briefly to the records themselves.

What is it that would justify the use of the term "scientific" as applied to a few of the oldest inscribed documents from Mesopotamia? The answer is bound up with the character and purpose of these special texts. Each of them contains lists of related entries. But these lists have nothing in common with the customary inventories of a strictly economic nature. They serve an intellectual rather than a material purpose. And yet, they are to enjoy a continuity and distribution which will set them off sharply from the usual run of business documents whose significance is at once temporary and local. The lists in question are destined to be copied and recopied for many centuries and in more than one city and country. Actual examples of such copies, often modified and expanded, but still in a clear line of descent from the oldest prototypes, have been discovered in Mesopotamian sites of much later age, and even in foreign capitals like Elamite Susa. We have thus before us the beginning of a family of documents of a scholarly char-

acter which are notable for their continuity, distribution and purposeful adherence to an established tradition.[1]

In this recording of accumulating experience and the manifest applicability of such records to the needs of cultural centers separated by political, linguistic and chronological barriers we have the essential ingredients of scientific performance. Now what science or sciences did this activity embrace? We shall see presently that the primary purpose of the lists under discussion was to aid in the preservation of the knowledge of writing. Before long, philological studies become an added objective, owing largely to the composite ethnic and linguistic background of early historic Mesopotamia. But natural sciences, too, soon come in for their share of attention.

For regardless of the primary purpose of our lists, they happen to include quite early in their history groupings of birds, fish, domestic animals, plants, and the like. It is worth stressing that these compilations presuppose careful observation and imply organization and analysis of the accumulated data.[2] As an element in the cumulative tradition of the land the lists are subject to steady expansion and improvement. What is more, although these texts were calculated originally to serve purposes unrelated to their subject-matter, they led in course of time to the independent study of the subject-matter involved. The fields affected are zoology and botany, and later on geology and chemistry. The first recognition of all these subjects as so many separate fields of study may be traced back, therefore, to the earliest inscribed documents from Mesopotamia. Interestingly enough, that recognition was due ultimately to the fact that man had just discovered in writing a way to arrest time and was applying all his ingenuity to the task of keeping this discovery alive.

The subsequent progress of the individual sciences just mentioned has to be traced by specialists. We are concerned at present with the initial impetus alone and the time and circumstances in which that impetus was first received. A few details, however, may be brought out in passing. In the light of the foregoing remarks botanists will not be surprised to learn that many of the terms which they use to-day are found in Mesopotamian sources. These terms include "cassia" (cuneiform *kasû*), "chicory" (*kukru*), "cumin" (*kamûnu*), "crocus" (*kurkânû*), "hyssop" (*zûpu*), "myrrh" (*murru*), "nard" (*lardu*), "saffron" (*azupirânîtu*), and probably many others. The zoological compilations which are accessible in cuneiform records contains hundreds of names systematically arranged and presented in two columns, the first giving the Sumerian term and the other its Akkadian equivalent.[3] The scholastic tradition in chemistry[4] results in such texts as the one which has come down to us from the second millennium B.C., wherein a formula for glazing pottery is preserved in the guise of a cryptogram so as to remain hidden from the uninitiated.[5] The importance of the natural sciences for the study of medicine is self-evident; it was not lost on Babylonian and Assyrian medicine.

So much for the indirect benefits derived from the lists under discussion.

[1] These facts are brought out clearly by A. Falkenstein, whose "Archaische Texte aus Uruk" (Berlin, 1936) is the basic work on the earliest documents from Mesopotamia; *cf.* especially pp. 43 *ff.*

[2] Careful observation is evidenced also by the accurate drawings of the early pictographs, particularly where exotic animals and specific plants were concerned.

[3] See Benno Landsberger (in cooperation with I. Krumbiegel), "Die Fauna des alten Mesopotamien" (Leipzig, 1934).

[4] On this subject *cf.* R. Campbell Thompson, "A Dictionary of Assyrian Chemistry and Geology" (Oxford, 1936).

[5] R. Campbell Thompson and C. J. Gadd, in "Iraq," III (1936), pp. 87 *ff.*

But the primary objective of these compilations was not allowed to suffer in the meantime. On the contrary, the direct results which were achieved with their aid led to an immensely fruitful advance in another field of intellectual progress.

It was stated above that our lists were intended as a means to preserve the newly attained knowledge of script. By the very nature of its origin in concrete pictographs early writing was an elaborate medium consisting of thousands of items. To each new prospective user it represented a code which could not be deciphered without a proper key. The lists were calculated to supply that key. They were analytical catalogues of signs arranged according to form. Inasmuch as each sign was at first a reflection of something specific in the material world, these catalogues were at the same time systematic groupings of related objects; hence their incidental value to the natural sciences, as we have just seen. The immediate purpose, however, of these arrangements was pedagogical; they are our oldest manuals for the discipline of education. As pictographs and ideograms gradually took on abstract phonetic values, the study of the script became linked perforce with the study of language. After the Semitic-speaking Akkadians had joined the Sumerians in building up the civilization of Mesopotamia, linguistic studies rose to exceptional heights against this bilingual background.

The deep-rooted respect for scholarly tradition which comes with a sense of dependence on the contributions of the past, implicit in the developments here outlined, had much to do with the unparalleled achievements of ancient Mesopotamia in the field of linguistics. For it meant that the Akkadians, Babylonians and Assyrians must fall back upon records in the unrelated tongue of Sumer. The knowledge of that language had to be maintained for cultural purposes long after its speakers had lost all political power, even after they had disappeared from the scene altogether. For the first time in history translators are at work to commit their renderings to writing. This activity called for the production of various auxiliary manuals: syllabaries giving the phonetic value, form and name of each given sign; vocabularies containing the Sumerian pronunciation, ideogram and Akkadian equivalent of each word or group of words; lists of synonyms, commentaries on selected ideograms, interlinear transliterations with given Sumerian texts, and the like. Nor was this all. The scientific analysis of Sumerian took the form of grammatical works arranged in paradigms according to the parts of speech and explicit down to such minutiae as the place of the accent. Differences in the dialects of Sumerian were carefully noted. And most of this formidable apparatus was available and in use four thousand years ago! It is to this apparatus that we owe our present knowledge not only of the various dialects of Sumerian and Akkadian, but also of such languages as Elamite, Hittite, Hurrian and Urartian. As linguistic material these languages may be of interest only to a small group of specialists. But as the media for expressing the thought of a large portion of the ancient world over a period of three millennia—a period one and a half times as long as the whole of the present era—they have a deep significance for the entire civilized world.

The foregoing outline has had as its main theme the demonstration that many forms of scientific progress in Mesopotamia were influenced and linked together by a scholarly tradition which was in turn the by-product of the invention of writing. Our survey has failed, however, thus far to include mathematics and astronomy, two fields for which Mesopotamia has long been celebrated,

and is so now more than ever owing to the researches of Professor Neugebauer. It goes without saying that these subjects were affected no less than the other disciplines by the same forces which made for a broad cultural advance in general. But the primary cause of the extraordinary development of mathematical and related studies in Mesopotamia is to be sought, I believe, in conditions which antedate the introduction of writing. In fact, I would add, the origin of writing as well as the interest in mathematics are to be traced back, in this case, to a common source. This source will be found inherent in the society and economy of the prehistoric Sumerians.

We know to-day that the Sumerians got their idea of writing from the cylinder seals which they engraved with various designs to serve as personal symbols. These symbols came to be employed as marks of identification for religious and economic purposes, for example, with temple offerings. In this representational function the old designs develop into concrete graphs for humans, animals, plants, and so forth, and thence for temples, gods and cities. The graphs are then associated in each instance with specific words. The gap between picture and word is bridged. Gradually means are devised to express not only complete words but also component syllables, the advance leading thus from the concrete to the abstract. At length writing is perfected to function as a flexible medium for the recording of speech and thought.

When we look back now on the successive interlocking stages in this complicated process, which has been sketched here in its barest outlines, an interesting fact will emerge. The early Sumerians had not set out at all to invent writing. They were led to this result by a combination of peculiar circumstances. The outcome had scarcely been planned or foreseen. The achievement of the discoverers lay chiefly in their ability to recognize and seize their opportunity. This they did with truly remarkable ingenuity and perseverance. That they had the opportunity to begin with was due, however, to the way in which their society functioned. This system can now be reconstructed from a wealth of diversified evidence. Only a rough summary can be attempted at present.

We have seen that the immediate ancestor of Mesopotamian writing was the cylinder seal which was first and foremost the Sumerian's mark of ownership. Impressed on clay or cloth it served to safeguard in the eyes of god and man one's title to possessions or merchandise. We have here a clear indication of a strongly developed sense of private property and thereby of individual rights and individual initiative.[6] The curious shape of the cylinder seal, original with the Sumerians, is explained by its use as a mark of individual ownership. For such cylindrical objects are well suited to cover uneven surfaces with their distinctive design.[7]

Wholly consistent with this economic origin of writing is the fact that the earliest written documents are given over to temple economy. Later texts branch out into the field of private business. Both these uses testify independently to the importance attaching to property rights. Records of a non-economic character are the last to appear, except for the lists discussed above which served as direct aids to writing. The first inscribed documents were used, accordingly, for economic ends, precisely as the cylinder seals themselves. It is easy to understand why the oldest pictographs were so often identical with the designs on the seals.

It follows that Mesopotamian writing,

[6] *Cf.* E. A. Speiser, *Supplement* to the *Journal of the American Oriental Society*, No. 4 (Vol. 59, 1939), pp. 17 *ff.* (esp. pp. 25–28).

[7] See H. Frankfort, "Cylinder Seals" (London, 1939), p. 2.

and hence the first script known to man, was the unforeseen outgrowth of a social order which was founded on a recognition of personal rights. This basic feature of Sumerian society is attested overwhelmingly in cuneiform law, perhaps the most characteristic and the most abundant expression of ancient Mesopotamian civilization. In the last analysis this law rests on individual rights. It is not surprising, therefore, that proof of ownership becomes a vital necessity under this system. Incidentally, the rigid requirement of such proof is the main reason for the hundreds of thousands of legal documents recovered from the buried sites of Mesopotamia; the forces responsible for the introduction of writing continued thus as the primary factor in the subsequent popularity of script. The law applies to ruler and subjects alike. The king is at first no more than a "great man," as is shown by the Sumerian etymology of the term as well as the form of the corresponding pictograph. He may become the administrator of a vast empire, but even then he is still the servant, not the source of the law, and is responsible to the gods for its enactment. There is here no encouragement of absolute power. Law codes are the constitution which guides the ruler and safeguards the subjects. We have seen that this system is capable of promoting cultural progress on an extensive scale. Its inherent vitality is evidenced by the ease with which this order maintains itself for thousands of years in spite of a succession of political changes under the Sumerians, Akkadians, Gutians, Babylonians, Kassites and Assyrians. Nor is further expansion hindered by ethnic or linguistic obstacles in its path; for distant and heterogeneous outsiders are attracted not infrequently to the orbit of the Mesopotamian civilization. Among the newcomers we find the Elamites, the Hurrians and the Hittites, the last-named a people of European ancestry and Indo-European speech. Incidentally, it is to the influence of Mesopotamia upon the Hittites that we owe to-day our oldest available records of any Indo-European language. The newcomers proceed to copy the laws, use the script and enjoy the other benefits of the adopted civilization.

Enough has been said to imply that mathematics and time-reckoning were bound to prosper against this social and economic background. An obvious corollary is preoccupation with metrology, with the result that Mesopotamian weights and measures spread eventually beyond the domain of the parent culture. But the technical features of these disciplines do not lie within the scope of the present account.[8]

To sum up, there existed an intimate relation between scientific progress in Mesopotamia and the source of historic Mesopotamian civilization. Underlying all was a social order resting on the rights of the individual, embodied in a competitive economy, and protected by the supreme authority of the law. This system brought about the evolution of writing, henceforward a decisive factor in the advance of civilization and its diffusion across the changing ethnic and political boundaries. We have here the essentials of a truly cosmopolitan civilization notable for its assimilatory power and a science broad in scope and balanced through the inner unity of its many branches.

Would this story of scientific development have differed appreciably under another type of civilization? The answer is hinted in one of history's most magnificent experiments. The one center possessing a culture of comparable antiquity but dissimilar social and economic background was Egypt. Here the king was a god and as such the absolute ruler and titular owner of all that his realm contained. Under this concept of

[8] Note the article by V. Gordon Childe, on "The Oriental Background of European Science," *The Modern Quarterly* I, Number 2 (1938), pp. 105 *ff*.

government there was no room for the recognition of private ownership of property and the all-embracing power of the law. The pharaoh was dictator of a state genuinely and thoroughly totalitarian. The pyramids bear lasting and eloquent testimony to his enormous authority.

We are not concerned here with the respective merits of two contracting forms of government. Our interest is confined for the present to the effect of coexistent civilizations upon the progress of science in the two centers under comparison. The perspective of more than five thousand years can not but deepen our appreciation of the debt which modern life owes to both Egypt and Mesopotamia. By the same token, however, we are able now to view objectively some of the differences between their respective achievements.

The established superiority of Mesopotamian mathematics may be attributed, in part at least, to the stimulus of the local economy, so different from the Egyptian. Opposed concepts of property ownership and the fundamental rights of the individual were responsible for the intensive pursuit of legal studies in the one instance and their subsidiary role in the other. The astounding accomplishment of Mesopotamia in the field of linguistics had no adequate counterpart in Egypt. Now we have seen that in Mesopotamia progress in linguistic studies, not to cite now other branches of science, was linked intimately with the development of writing. But was not Egyptian writing a correspondingly potent factor?

If this question can not be answered with complete confidence it is largely because the origin of the Egyptian form of script is still open to conjecture. Some details, however, are certain and beyond dispute. The earliest inscribed records of Egypt are some centuries later than the first written documents of Mesopotamia. In Sumer we can follow the successive paleographic stages step by step, whereas in Egypt the formative period of writing seems to have been very short indeed, to judge from the available material. Moreover, writing left in Sumer a clearly marked trail which leads back to a specific social and economic set-up; in Egypt there is no such demonstrable relationship. Because of all these facts, and in view also of commercial and cultural links known to have connected Egypt and Mesopotamia at the very period under discussion, it is logical to assume that Egypt imported the idea of writing from Mesopotamia. Differences in the form and use of the signs would correspond, then, to the existing differences in the art and languages of the two cultural centers. On present evidence, any other assumption would leave far too much to coincidence.[9] In the final analysis it is not so much a question of the mere use of script as of the conditions responsible for the original emergence of writing.

At all events, Egyptian writing, regardless of its origin, inevitably played its part in the notable progress of Egyptian science. What we miss here, however, is the scope and inner unity of scientific advance which we found to be so characteristic of Mesopotamia. That unity was the product of a tradition which is traceable ultimately to a particular concept of life. In totalitarian Egypt a different set of values attached to life and government and tradition. Is this the reason for an effort that seems more sporadic, greater perhaps in its power of concentration on specific objectives, but also more conspicuous for its omissions? Over a period of millennia this appears to be a justifiable comparative appraisal of the results achieved in the field of science by the two oldest historic civilizations.

[9] *Cf.* Speiser, *op. cit.* 22, note 12, and Siegfried Schott, in Kurt Sethe's "Vom Bilde zum Buchstaben" (1939) pp. 81 *ff*.

THE RELATION OF ETHICS TO HUMAN PROGRESS

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Ethics Derived from the Laws of Nature

The actions of every living being are guided by its search for happiness. Prudence, sagacity, discretion, shrewdness, sympathy, judgment and at last wisdom govern the conduct of life in successively higher stages, but through all these there runs the constant thread of striving to be happy. More than any other factor, the desire for happiness is the motive power of evolution.

During the centuries of recorded history, men have repeatedly developed new principles of conduct, such as the Ten Commandments of Moses, the teachings of the church, and national or party doctrine; but the pressure of events has forced continual change. Under new conditions the old rules no longer provide the accustomed benefits, unhappiness ensues, and revolutions follow closely, yielding in turn new codes of ethics. As time goes on, these codes deal more and more with social objectives and group behavior, going far beyond the personal morality of our ancestors. Now, more than ever before, men feel a need for principles of right conduct, attuned to changing conditions, and based on reason rather than tradition. Certain it is that the day has gone by for general adherence to static rules of conduct laid down by any authority.

In my own experience as an engineer, I have been continually impressed by analogies between the recorded progress of evolution, the processes of growth, and the phenomena of fluid flow, all of which proceed in accordance with inexorable natural laws. There surely must be, therefore, some general principles of ethics which can be derived from observations of nature; just as we have derived the laws of geometry and of motion. Such ethical principles must bear a close relation to the laws of survival which underlie the processes of organic evolution, and ought to be more useful in guiding human affairs than pronouncements from dictators of whatever sort.

The engineer's philosophy, or correlation of ethics with evolution, that has grown out of this process of observation and study is briefly summed up in seven statements, or theses:

(1) Right conduct consists essentially in promoting the progress of evolution; that is, living in harmony with the laws of nature.

(2) Evolution consists in the development of more numerous, more varied, more specialized, and more highly organized living types, existing at higher comfort levels; or, in a few words, the creation of greater happiness for greater numbers.

(3) The twin measures of progress in evolution, therefore, are the progress of engineering, or the beneficent control of nature by man, and the degree of happiness existing.

(4) The best assurance of individual happiness is the free exercise of all one's abilities.

(5) The best assurance of engineering progress is the free exercise of all human abilities, with that balance between individual and collective efforts best suited to the existing state of evolution.

(6) Both group and individual abilities are greatest when specialization is effected, as permitted by the cooperation

resulting from sympathetic understanding.

(7) These abilities are most freely exercised when human society is stable, but not stagnant, as occurs when honesty is the rule of living.

The precepts of the natural ethics thus derived from observations on human evolution stress the positive virtues of productive activity, cooperation and honesty, on the pragmatic grounds that they promote progress; rather than the negative virtues of abstinence, meekness, thrift and charity, which have received traditional emphasis. The conclusions reached are not especially new, but they offer a basis for more logical and practical morality than purely authoritarian precepts.

The Nature of Right Conduct

How to tell right from wrong is a problem of age-old difficulty, which must largely be answered by each individual on the basis of his own experience. In the animal kingdom, ethics rarely transcends the level of "sauve qui peut," but men must weigh the rights of others against their own, and the present against the future.

In modern business, knotty ethical questions are continually arising, which demand the highest wisdom for their just solution. Two examples from the experience of an old contractor may not be amiss in this connection. In bidding on alterations to a church, he met severe price competition, but felt that he could not afford to reduce future price levels by publicly reducing his bid. On the other hand, he felt that for his men's sake he must secure the job, even at a loss to himself. He, therefore, privately donated to the church funds a sum equal to the expected margin above bare costs, and so was awarded the contract. Did he, or the church authorities, or both, do wrong in this case? At another time, he was awarded a large contract on the basis of a low bid, but soon found that he had greatly underestimated the cost of the work. Instead of trying to evade the contract, or skimping it, he carried it through in the best manner, and then made a frank statement to his employers of the amount by which the cost exceeded his bid. They were so well impressed that they awarded him the additional amount. Here, certainly, was sound morality on both sides.

Up to a century ago, most philosophers based their ethical theories on divine revelations, or metaphysical assumptions, and then proceeded to judge historical events and human actions as right or wrong according as they did or did not agree with these arbitrary principles. After Darwin and Spencer, however, the tendency has been to take survival as a chief criterion of right. Who will assert that the extinction of the dinosaurs and the rise of the human race were morally wrong, and how do these facts of survival differ in ethical value from the submergence of the American Indian by the tide of white civilization?

The principles of evolution govern the survival of the fittest groups, and not merely the fittest individuals. Actions that have a maximum survival value evidently create maximum activity and expansion, or general well-being, and, therefore, they promote happiness of the group in question. It appears, therefore, that the development of sympathy and other altruistic motives has come about as naturally in the evolution of group abilities through specialization and cooperation, as the development of egoistic motives came about in the earlier evolution of individual abilities. Thus, all human motives have been concomitants of progress in civilization, and the ethical principles of right and wrong must be determinable from the direction taken by human progress.

Our basic inquiry must be, What is the purpose of our existence? Well, viewed from the present day, the only tangible object of the existence of Nean-

derthal man and his contemporaries was surely to produce ourselves. So, from a cosmic view-point, and excluding the possibilities of life after death, we exist to carry on in the development of our ultimate descendants. The production of material objects, transitory and non-perpetuating as they are, can not be considered an object of human existence. Nature proceeds slowly, but inexorably, and this process of organic evolution that has produced us from primitive ancestors will continue in the future, as surely as night will continue to alternate with day. The purpose of our existence is to progress in the train of evolution toward an unknown goal, which can not be foreseen, and which it is futile to imagine. All we can do is to proceed as rapidly as possible along the tangent to the curve of world evolution, as closely as we can determine its direction.

If the purpose of our existence is known, the question of right and wrong is settled. It is right to further that purpose, and wrong to oppose it. It may be suggested that man is being relentlessly carried along in the stream of evolution, and that it is his duty to struggle against it with all his might, hoping finally to hold his own, or even to turn time backward in its flight. Such a theory is untenable, however, as contrary to all our experience of good and evil results from human actions. When we foresee the coming storm and take shelter in time, we avoid destruction; when we plant with due regard to the coming of spring, we reap an autumn harvest; and so in all things we prosper by harmonizing our actions with those of nature. But it is vitally necessary to distinguish between a change that is true progress; and the destructive changes, or reversions toward barbarism, which are the opposite of progress.

The more we contemplate this question of right and wrong behavior, the more we realize that it is not simply a question of ethics, but of wisdom in judging the probable future effects of present actions. It has been well said that the essence of wisdom consists in being interested in subjects and devoted to ends in degrees proportioned to their intrinsic and relative importance. In this sense, a wise man will never allow himself to seek a personal good save in conformity with the conditions of universal good.

The Nature of Happiness

Let us now compare the simple principle that right consists in furthering the progress of organic evolution, with the abstract idea of moralists that right consists in the promotion of human happiness. To an outside observer, who did not himself feel the emotions of pleasure or pain, the theory that happiness could itself be an object would be unimaginable, though he could readily appreciate the tangible object of life expansion in which evolution consists. However, is there not a close correlation between the promotion of happiness and that of evolution?

Happiness broadly consists in the free exercise of one's abilities. Any restrictions cause unhappiness, whether imposed by man or nature. Any unused ability leaves undeveloped a source of greater happiness. I do not doubt that even the termite, condemned to incessant toil in subterranean darkness, derives a strange joy from its monotonous activities, that makes its life worth while. The state of greatest happiness is that in which the world's abilities are being most freely and fully exercised, in work and in play.

A child, forgetful of the past and unmindful of the future, finds perfect happiness in romping with his playmates. The happiness of an adult, however, requires satisfaction of his abilities to enjoy past remembrances and future prospects, as well as fulfilment of his immediate desires. The more complex a personality, and the more varied his abilities, the more difficult it is to secure

a balance of satisfactions, but the more intense and elevated the happiness it is possible to attain. Through the ages man's happiness has progressed from the exultation of the savage after a successful hunt to the enjoyment of the builder in the completion of a great structure—from a momentary thrill to a sustained satisfaction—but always the greatest joys have come in the completion of constructive efforts.

It is reported that Genghis Khan once asked a young officer of his guard what his ideal of happiness was. After some thought, the young man replied, "To ride on a swift horse over the open steppes with a falcon on the wrist." "Nay," the Khan replied, "it is to see your enemies fall before you and hear the lamentations of their women."

There are so many kinds of pleasure, therefore, some transient and some lasting, that to seek happiness directly gives no definite objective. To further progress by exerting constructive efforts brings happiness as a by-product, but the pursuit of pleasure is by no means sure to promote human progress. The defect of the hedonistic principle is that no guide in the selection of pleasures to be sought after is provided. This is remedied by the conscious endeavor to promote evolution itself. Our system of natural ethics includes the best features of the Calvinist and the Hedonist philosophies.

To promote the slow process of evolution, it is clearly necessary to look to the future, to sum up all the effects, far and near, of our actions, and to weigh carefully the net progress resulting. The principle here enunciated is that those actions contributing most to evolutionary progress are right, but it is also indicated that the same actions will produce the maximum total of happiness. Thus, transient pleasures may as often be wrong as right, but enduring pleasures founded on achievement are surely right. By keeping in mind the promotion of evolution as the objective, we are enabled to lay down a true tangent to the curve of progress, as viewed from our own situation. By seeking immediate happiness alone, we may be as far from the true direction as if we took the direction of a single mile of the Mississippi for the true course to its mouth.

The increase of our abilities as evolution proceeds brings with it an increase in our capacity for happiness, which indeed may be measured by the extent and variety of our abilities. Our capacity for suffering is likewise increased, and in periods of retrogression the net effect may be an excess of suffering. But this can only result from a great restriction in the exercise of human abilities; so that it seems a truism to say that the rate of progress of evolution is in the long run proportionate to the existing degree of happiness.

Acceptance of these principles brings at once a train of interesting corollaries. As the abilities and needs of an elephant, a Kaffir and an Eskimo differ, so do the acts which make them happy or promote their progress vary. How widely, then, must their standards of rightness differ, standards which will most conduce to increase in their respective states of ability! What is right for the German is not necessarily right for the Chinese; though with increasing similarity of abilities the standards of rightness are also more alike. From this view-point the absurdity of imposing civilized moral standards on savages is apparent.

Also, we can see that conflicts between nations must arise, even though both act with perfect rectitude according to their own limited standards. The more complex questions of the justice of particular conflicts, and of the right standards for mixed populations, require further recourse to observation of nature's methods. The central fact of evolution is the increase of total fitness for living, or, as applied to man, of his control over nature. When a higher race supplants

a lower one, the world's fitness total is increased, but when the lower race is destroyed or repressed, the total fitness is decreased by that amount. There can be no exact statement of the ethical ideal, but there is clearly a best compromise, in which the lower race allows the higher one to occupy its territory, the higher race aids the development of the lower one, and finally the abilities of the two are perpetuated in association. Thus, a war of aggression is wrong, but so is it wrong to bar unused territory from development; or bar progress by other means; so that wars, revolutions and strikes may often be more right than wrong. As long as groups of men of widely different abilities live apart from each other, so long will conflicts of actions that are right for each of them occur and wars continue.

The conclusions derived from our study of human progress, thus far, are that rightness consists in promoting the free exercise of ability, and this in turn provides true happiness. And the state of evolution is measured by the amount of the world's abilities, the rate of progress of evolution is indicated by the degree of happiness and the rate of acceleration of progress by the degree of rightness existing in the world.

The Nature of Progress

To decide any actual question of right and wrong, it is necessary to define more clearly what progress in evolution is. Progress is like the growth of a giant oak—there are many branches, and no one can say which twig will be the foundation of the greatest future growth. In a broad way, the tree's branches all point upwards, and each year the number and complexity of the offshoots increase—similarly in human evolution progress is always toward greater control over nature and greater variety of man's abilities. This view, therefore, may tell us broad distinctions between right and wrong, but tells also that many different actions are right under different circumstances, and gives us only a hint in the many cases where right and wrong are nearly balanced.

Just as we predict the future growth of a branch of the oak will be along the direction of its present extremity, so the historian studies the records of the past to deduce from them the trend of progress, and so to focus human efforts on practical objectives. Of all the lines of progress made by man, there is none more evident and continuous than the increase of his control over nature, so that we may accept it as a fact that progress in this direction will continue in the future and at an increasing rate. The key to human progress, therefore, and to determination of ethical actions is an understanding of the way in which engineering progress occurs.

Man's control over nature has come from three distinct sources: first, his individual abilities developed through ages of competition; second, his ability to cooperate with his fellows, and thus to specialize; and, third, his ability to provide stable human relations during which constructive projects can be planned and carried out.

Man's individual ability developed at first through the struggle for survival, and later through more and more intensive education. As any further increase in ability is certainly in the direction of progress, we conclude that promotion of education and health are foremost in ethical precepts. Whatever improves either of these two factors is morally right and deserving of all support.

The ability to cooperate, which has so vastly increased man's powers above the aggregate of individuals, has come as a by-product of the development of specialized abilities. Having developed any special skill, a man derives more pleasure from its exercise, both directly and in return for his labor, than in other ways, and so he concentrates on it exclusively so long as he can get others to supply

his additional needs. To effect this exchange of services, cooperation is required, and by continual exercise of this cooperation the skill in working together improves further.

As in the case of any sport, skill is acquired by practice, so that the more one specializes in any useful task the more production can be increased, and so the process is cumulative. Each increase in ability encourages further specialization, and requires greater cooperation, so increasing the variety of skills, the adaptation to surroundings and general fitness for life. In this way, evolution progresses ever more rapidly in each isolated community, until some limit of resources is reached or some conflict with other groups interrupts the course of events.

Cooperation and Sympathy

In just what does the ability to cooperate consist? Evidently it consists not merely in the ability to transfer knowledge from one mind to another, but also in sympathy, the ability to understand and appreciate the feelings of another. Sympathy is the prime requisite for cooperation. The faculty has developed along with the specialization of functions, and its great survival value, due to the increase of power it permitted, has promoted its high development in the dominant races. Admitting only the initial existence of the will to live, and the observed fact that exercise of an ability strengthens it, the development of sympathy follows in the course of evolution as naturally as that of any other of man's varied abilities. The immediate motive to act in accordance with the dictates of sympathy comes from the transference of the feelings of another to one's self and the consequent experience of pain or pleasure. A deaf man may enjoy a concert simply through the pleasure communicated by the expressions of others, and such communications of feeling are felt particularly strongly when watching children, because of their simple emotions and frankness. How much greater enjoyment is possible to one who can feel at once the pleasures of a hundred others, than to another whose lack of sympathy limits his feelings to the pleasures of his own five senses! Sympathetic actions may be called selfish in the second degree, since they are performed to relieve one's own feelings, even though these feelings are simply mental reflections of another's realities.

If this view is correct, the development of sympathy must be one of the most characteristic phases of man's later progress, and its further increase is of the highest practical importance. It is, therefore, worth while to see what we can find out about it from a brief review of history.

It is certain that ages ago men were far less capable of sympathy than they are to-day. Herbert Spencer has suggested that so long as men are hunters and warriors exposed to continual contact with suffering and death, the ability to sympathize with others must remain undeveloped, since exercise of it leads so often to pain. It seems more likely, however, that all developing races have had enough surplus of happiness to make the exercise of a selective sympathy predominantly pleasurable, at least between members of the same race, but that the real development of this ability began when it acquired an important survival value through permitting specialization.

The earliest development of sympathy was between mothers and children, and later it appeared between members of a tribe. The nurses in an ant colony will fondle the baby ants in their arms most affectionately, but will kill strange ants on sight. Savages enact barbaric rites without feeling the least sympathy for the victims, although they regard their relatives with affection. In deserts and very cold countries, where man can not progress beyond the stage of the hunter,

sympathy with aliens has practically no survival value and may even be detrimental, so here it may be ethically wrong.

An English magistrate in India some years ago in visiting a village in his district met with a curious example of this lack of sympathy with strangers. The headman in showing him around passed a steep-sided clay pit full of water, and on doing so began to laugh immoderately. After some difficulty in overcoming his mirth, he explained it by saying that a few weeks ago a stranger, passing by, had fallen into the pit, and had attracted attention by his cries as he tried to get out. The villagers had gathered about and had been so amused by his strange cries and struggles that they had rolled on the ground with laughter until finally he disappeared beneath the surface. It had never occurred to them to help him, much less to recover his body afterwards. This insensitivity to the suffering of others seems to have been quite universal not many centuries ago, so that the development of our present sympathies is one of the happiest signs of continuing evolution.

I believe it was St. Thomas Aquinas in the thirteenth century who held out to his disciples the hope of an especial reward of virtue, consisting in having a front row seat among the angels in heaven, where the tortures of the damned could be enjoyed most heartily. If a saint had such feelings, the populace could scarcely have been sympathetic, and I venture to say their powers of cooperation must have been very slight.

Even after a marked degree of sympathy with other human beings has developed, a complete insensitivity to the feelings of animals has existed. Only recently have the pleasures of hunting come to seem somewhat barbaric, and as late as 1840 a conjurer in Paris achieved great popularity by publicly executing numbers of pigeons and canaries and performing sleight of hand tricks with their remains. Such insensitivity to animal suffering must be a mark of a low order of human sympathy as well. Abraham Lincoln proved his great capacity for human sympathy when, dressed in his Sunday best, he encountered a pig stuck in the mud. After some consideration, he passed by on the other side of the road, but when he had walked a half mile his feelings for the pig had risen to such a pitch that he returned and helped the pig to dry land, at much cost to his clothes.

Elihu Root, when an old man, once said: "Even in my time compassion not only for human beings but also for animals has grown. I distinctly remember that, when Henry Bergh founded the Society for the Prevention of Cruelty to Animals, he was looked upon as more or less of a crank. To-day a man who is cruel to animals is regarded as a brute. It is this growth of compassion that I would say was the greatest change that has occurred in my lifetime."

While the personal capacity for appreciation of the feelings of others has reached a high level in the advanced races, it is still totally lacking in many parts of the world. Also, the capacity for sympathy between cities, states and nations is progressively less as the size of the group increases. Trade barriers, racial discrimination, oppression of minorities and war all demonstrate the inhumanity of large groups. Nevertheless, much progress has been made, and the potentialities of radio and television, airplane travel and improved news service in developing international understanding and sympathy are immense. At present, the perversion of radio and news services in dictator countries to exclusive development of national self-pity, and of hatred for foreign devils, is promoting nationalism at the expense of world progress. But history suggests this is only a passing phase, and that ultimately the ever better media of communication will bring sympathy and co-

operation between nations as well as individuals.

Progress of this sort is especially evident in business methods. A few years ago, the president of the National Electrical Manufacturers' Association offered a series of pledges to guide business competitors, in recognition of their responsibilities to the industry, the last pledge being "To refrain from introducing any practices to gain individual competitive advantage, which if followed by my competitors generally would be uneconomic or commercially unsound." Contrasting this typical modern business precept with the "dog eat dog" practices of early days, indicates how much has been gained.

Broadly speaking, as evolution progresses, interrelationships multiply, and the economic gain from cooperation increases at a continually greater rate. The ethical precept that any act which promotes the growth of sympathy is right, therefore, coincides with the trend of progress in civilization.

Honesty

In nature, growth is slow, destruction is rapid. An earthquake, a fire or violence may destroy in a moment the work of many years. So also in human activities, any constructive enterprise requires much time for planning, organizing and executing. Just as a plant can not grow if its roots are continually disturbed, so human affairs can not go forward unless there is a reasonable degree of stability in society.

The essential criterion of stability is such continuity of physical conditions, laws and contracts that predictions made well in advance will be reasonably fulfilled. When men can not foresee a favorable outcome of their ventures, enterprise fails and business stagnates. Nothing is more destructive of human progress than sudden or arbitrary changes in conditions, whether by criminal act, war, or caprice of a dictatorial government.

Honesty is the human trait which provides this stability. The Anglo-Saxon business tradition that a man's word should be as good as his bond is the cornerstone of progress in civilization, since it has enabled vast business enterprises and creative undertakings to be carried through with assurance. The Machiavellian precepts of double dealing, on the other hand, have given rise to the saying, "Put not your trust in princes," which applies as well to modern as to ancient dictators.

Without honesty, all forms of saving and consequent earned leisure are greatly retarded. Wherever men's promises can be relied upon, and property is safe from thieves, it is possible to store up reserves, undertake new ventures and organize far distant forces to cooperate in great undertakings. Where thieves and liars rule, men's energy is diverted from constructive to defensive actions, no man saves ahead for fear of loss, and society disintegrates into warring factions.

The true criterion of honesty is not merely adherence to a code of ethics, but acting in such manner as to promote long-term constructive activities. When Schopenhauer justified lying in self-defense, therefore, and Talleyrand went so far as to say that words were given to man to conceal his feelings, they were not completely unethical. Honesty in the sense of our natural system of ethics requires adherence to contracts openly arrived at, at whatever personal disadvantage, since such conduct enables the world's business to go on. It does not require, however, that we cooperate in the same manner with an enemy or thief who has invoked the law of the jungle by an act of violence that has disrupted our affairs. Honesty is a by-product of cooperation in much the same way that cooperation is a by-product of specialization.

Conclusions

It is rather striking how the great importance of sympathy indicated by these principles, deduced from the progress of evolution without regard to metaphysical or religious codes, agrees with the emphasis laid on mercy by the Christian religion, on compassion by Schopenhauer and on the same general motive by many other philosophies.

It has not been possible in these few pages to adequately show the relations between human progress and the activating motives which have gradually brought it about, but at least there has been indicated the possibility of a dynamic science of ethics which defines right human actions as those conducive to progress at the time. In primeval times, the exercise of sympathy and honesty can have been of very little importance in the promotion of evolution, and so they were not as ethically important as the exercise of strength and activity. Now, however, the peaceful and helpful intercourse between nations, which is so essential for world progress, requires greater sympathy and honesty on the part of the dominant groups than ever before, and the same qualities are daily more necessary in the conduct of modern business.

The whole point of view that correlates ethics with progress leads away from the old dicta that whatever is is right, and whatever was was wrong, to the new one that whatever is was right. Whatever has come to pass through the processes of evolution has by the very fact of its survival been the product of acts that were right at one time, but the mere fact of their association with conditions no longer tolerable is presumptive evidence that they are right no longer. What is right is change along the lines of progress mapped out by past events.

Applying these precepts to modern society and the present world conflict leads me to hearty concurrence with the ideas of Walter Lippmann, as expressed in his treatise on "The Good Society," and with those of Wendell Willkie, as expressed in many public utterances. The necessities of free enterprise for progress, and of sympathy for cooperation, are so great that I consider the collectivist philosophy of regimentation from above essentially destructive. It is true that codes of fair practice and regulations of many sorts are needed to prevent liberty from degenerating into license, but these will develop far better through growth than by compulsion. Very many useful projects and educational advances are prohibited by any dictator type of government for every one that is aided, leading to ruthless oppression of the most enterprising people, with the inevitable end result of poverty, war and revolution. Dictatorships are as archaic in this modern world as the empire of Darius. They represent, however, the ambitions of millions of men who think by this means to improve their condition, and a crucial struggle for survival is now under way between the two systems. All of us are taking part in this struggle, in one way or another, giving ample cause for renewed thought on what is right and what is wrong.

It is no longer possible to secure general adherence to arbitrary principles of right and wrong laid down by authorities. To build up anew an ethical sense that can permeate a whole nation, it will be necessary to develop a scientific and dynamic ethical theory that justifies the actions of our forefathers as right in their time, but shows us that continuing evolution has made it right for us to be far more sympathetic and more honest than our ancestors could ever have been. One of the greatest opportunities in modern education is to build up such a theory and teach by historic examples the real value of cooperation and the harm done by dishonest actions.

THE PHILOSOPHICAL BASIS OF PEDIATRICS

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Some of my readers may have been told that pediatrics is a branch of medical science, and may be wondering at the audacity of a mere doctor of philosophy in venturing to discuss a topic which so plainly falls within the province of the *real* doctor, meaning, of course, the doctor of medicine. However, let me at this point give the reader a word of caution: don't believe everything that is told you! The pediatrics which I wish to discuss very briefly here is the science of the P.D. This is not, however, the P.D. that some of you may be thinking about—the one whose equation you have seen in learned treatises on electricity. No! the P.D. of the present discussion belongs neither to medicine nor physics, but to demonology.

Now before the reader dismisses demonology as mere superstition or plain nonsense, let me ask him to do a bit of introspection. Are we not all demonologists at heart? Why do we—every one of us—indulge in profanity when anything goes wrong? Is this not a vocal protest against some malevolent influence that we feel, for the moment, is balking us and thwarting our efforts? Let us not try to tell ourselves that we never really believe such a thing. I insist that, for the moment, we do really believe it—the moment when those sulphurous words are rolling off our tongues. One's spontaneous utterances reveal one's beliefs in a very true sense, even though some of these beliefs may be quite ephemeral. It is the burden of my present discourse that these momentary beliefs are actually fleeting glimpses of reality.

In theory, we all have complete faith in rigid causation. When the causes are the same, we say, the effects must be the same. But this is contradicted by everyday experience. Most of all, is it contradicted by the experiences of us scientists who are loudest in proclaiming our faith in universal law? In repeating a laboratory experiment, for example, precisely the same procedure is frequently followed by very different results. On such occasions, of course, we piously assume the existence of some undetected difference in the conditions with which we started. But is not this mere dogma or downright superstition? The science of pediatrics is founded on the frank recognition that such is the case.

During the nineteenth century, a thriving branch of mathematics was based upon the assumption that the geometry of Euclid—or part of it—was phony, that parallel lines would be found to meet if only one had the patience to follow them on forever. In the present century, too, we are told that if one traveled at the speed of light, he could make a trip entirely around the universe, retaining his own youth meanwhile, but finding, upon return to his starting-point, that everyone else had grown old during his absence. And again, a British astronomer, so celebrated that he appends nearly the whole alphabet to his name, has gravely assured us that "the number of particles—electrons and protons—in the universe is of the order of 10.^{79}" Alas, those figures are already out of date, since at least three new species of sub-atomic particles have been described since that census was taken!

Thus, in founding our science of pediatrics, it is plain that we need not be hampered by any considerations of common-sense. Why may we not assume

that causality needs, in its operations, a silent partner, the P.D.? Before going further, however, I must digress to explain what those mystic letters stand for.

The circumstances which prompted their first utterance will furnish a typical illustration of pediatric phenomena in general. It happened on the Florida coast, in the days when I was trapping *Peromyscus.* Three years earlier, in the same territory, with the same traps and bait, I had no trouble in catching any number of these fascinating little rodents. Now they simply wouldn't enter the traps. Not that they were scarce where we were trying to catch them. Their tracks were abundant everywhere, right up to the doorways of our traps themselves. Days passed by without success. Our time was limited, and much money and effort had been staked on this enterprise. My scientific reputation was on the point of reaching a new low. The situation began to look desperate. It was at the close of another of these days of failure, that I remarked feelingly to my assistant—and I meant it!—that whether or not I believed in a personal deity, I certainly believed in a Personal Devil. And thus was born the P.D.—Devil or Demon, according to your taste.

Our P.D. is not to be confused with the celebrated "Demon" to whom the physicist Clerk Maxwell assigned the task of sitting beside a trap-door between two chambers filled with gas, and sorting out scurrying molecules of different velocities, admitting them to one compartment or the other according to their speed. This demon's only accomplishment was to thumb his nose at the second law of thermodynamics. Our P.D. is a far more versatile being than that, extending his activities throughout the entire universe, wherever there is mischief to be done. The name of the new science which deals with his activities is, as my friend and colleague Dr. D. L. Fox points out, a particularly fitting one, for it plainly means P-D-at-tricks.

To return to our rodents, the spell was eventually broken—how this happened, we don't know—and we were able to ship home a sufficient number of the animals. But that is no part of the present story. For more than a week, the P.D. had complete command of the situation.

There are those who seem to be far less interfered with by the P.D.'s machinations than I am. Perhaps they sprinkle holy water around more freely than I do. In the laboratory, such persons always seem to get out of their experiments exactly what they are looking for. Everything is consistent and in accordance with theory. Inconsistencies and exceptions simply do not exist in their universe of discourse. At times, I cannot help envying such persons. But I am always suspicious of them. This world simply isn't constructed that way.

For honest people like you and me, a typical series of experiments runs about as follows. Our first attempt gives us precisely what we want. The second one confirms our first finding. We begin to get excited and glimpse visions of mighty achievement. However, for a time, we prudently keep our silence. But after another confirmation, we call in our friends; possibly we even commence our manuscript. It is at this point that the P.D. takes the wheel. As a result of some unknown cause—for we still think in terms of causes—things begin to go wrong. Exceptions pile up until they outnumber the rule. Our discovery turns out to be just another mirage. We may spend the next few days or weeks trying to find out which one of our experimental conditions has been unintentionally altered. But we rarely succeed. The real variable is something immaterial. Its name? I have already told you.

Any resemblance between this pedi-

atric doctrine of mine and the so-called "uncertainty principle" of Heisenberg *et al.* is, as the radio men say, "purely coincidental." The P.D. never allows himself to become entangled in a maze of mathematics such as enmeshes the uncertainty principle. He stands forth stark naked for what he is, to be judged on his merits, if any, by the most hopelessly non-mathematical person amongst us.

Every science has its "laws," or principal generalizations, to which its data lead. Thus far, only two laws of pediatrics have been firmly established. Others may be discovered in time. Here are the First and Second Laws of Pediatrics:

Law 1. Identical causes lead to identical results only in so far as an immaterial principle, the P.D., permits them to do so.

Law 2. This principle is malevolent, in the sense that these interferences with the principle of causality tend toward the maximum thwarting of human desires.

Trivial illustrations of these principles meet us at every turn. For example, the oft-confirmed fact that if we try to open an unfamiliar lock with the keys of a bunch, the correct key is nearly or quite the last one to be selected. Stated in more general terms, if we have n objects of a particular sort in a group, and if we wish to find some one of these objects, say b, by random selection, the probability is high that we shall not find this object until we approach the nth member of the series.

I must admit that I have thus far failed to obtain decisive statistical proof of this proposition, however well supported it is by all human experience. That is not strange, however. One must not try to employ scientific standards in a pediatric world. Or to speak more technically, a scientific yard-stick can not be applied to a pediatric frame of reference. (Here again, let me insist that any resemblance between this line of reasoning and that employed by expositors of the relativity theory is purely coincidental).

All this means the downfall of classical science—the science of unswerving causality. Soulless materialism no longer shall rule our minds, and freedom asserts itself once more in the universe. Of the various freedoms concerning which we have heard so much in recent months, there are three which chiefly interest me. These are freedom to jest, freedom to ridicule, and freedom to try the patience of one's readers. But the last of these is the most precious of all. Farewell!

BOOKS ON SCIENCE FOR LAYMEN

ONE HUNDRED YEARS OF MEDICINE[1]

In the words of the author, this book "traces the major ideas upon which present-day medicine is founded." Great discoveries are rooted in the ideas current at the time. Although, as the title indicates, the author deals chiefly with events in the last hundred years, he takes the reader back into earlier centuries for the background of his account. The book traces the successively developed ideas of the cause of disease: "the wrath of God;" living contagious agents; food deficiencies; endocrine disorders, and finally the idea of psychic causes of disease, and the yet to be studied part played by the "soil" in which the seeds of disease fall. It traces the efforts at conquest associated with these various concepts. The author describes not only the progress of medicine, but also the concurrent opposition and obstruction that have beset all progress, and accounts for some of this, at any rate, in the momentum of ideas that leads even men of intelligence to brush aside new notions with impatience. The momentum of the concept of germ causation of disease delayed for long the recognition of food deficiencies as causes. "The world of science was not as yet responsive to ideas on non-bacterial, non-toxic disease causation."

The book is not solely a history of ideas. It contains many names and dates, and certain great personalities are treated at some length, notably Pasteur, Ehrlich, Koch and Freud. The author points out, however, that the "heroes in medicine" owe much to the stream of thought in which they were born, arising as they do at "nodal points in time." An idea may be expressed by some earlier seer even centuries before that "nodal point in time," but then only, reexpressed or even rediscovered, does it win the recognition that establishes it securely in its science. This thought is illustrated by a number of examples, from Hippocrates down to modern times.

The author is obviously impressed with the dramatic importance of some of the events he chronicles, and has the necessary command of words to convey this to the reader. Speaking of the Black Death: "Not soon forgotten was this visitation, nor those which down to almost our very own age periodically afflicted the world. Grey-haired men told of the 'pestilence' to their sons, and they in turn to their sons; and dread was upon all men. A pale horse, the fourth of the Apocalypse, rode upon the winds, and he that sat upon it was death."

The author brings out some interesting facts in the history of sepsis in surgery. From about the second century, A.D., surgery began to fall into disrepute, and finally was abandoned to the barbers and even to traveling charlatans. Only in the eighteenth century was it taken up again by reputable medical men. The author attributes its decline in the Dark Ages to the rise of sepsis in those centuries. The Hebrews, Greeks and Romans were clean peoples, but the Europeans in this era had become almost deliberately dirty. This is attributed to the development, under the influence of Christianity, of the idea of "mortifying the flesh"—by dirt and vermin.

Strangely, it appears that in the middle of the nineteenth century, after John Hunter had restored surgery to respectability, deaths from sepsis rose enormously. Mortality from amputations in Scottish hospitals, previously 8 per cent. or less, rose to 33 per cent.; and Lister's amputations had a mortality of nearly 50 per cent. before he began the development of his antiseptic methods.

[1] *Progress in Medicine.* Iago Galdston. ix + 347 pp. 1940. $3.00. Alfred A. Knopf.

It is interesting to contemplate that the field of nutrition was considered to be "worked out" at the beginning of the present century, when the work that must be regarded as starting the avalanche of present-day vitamin research had just been finished. Eijkman in 1897 had proved that a diet of polished rice resulted in the development of beri-beri. The scientific world slowly woke to its significance, and the science of nutrition had a rebirth. It "has helped free medicine of its germ-obsession, by demonstrating that there are diseases due to causes other than the contagium vivum. It has drawn attention to the soil as against the seed, compelling a revision of thought on the disease-producing powers of germs and their toxins."

The author gives an interesting account of the history of endocrinology. The idea that some part of an animal's body, when fed to a patient, affected favorably the same part of his own body, goes back to antiquity. As early as 1660 Thomas Willis proposed that the genitals contribute something—"a certain ferment"—to the blood, that gives the blood a "lively virtue." In 1858, Brown-Sequard experimented with the adrenals, and years later administered testicular extract to himself. In endocrinology, however, as with the vitamins, the impetus for wide-spread research came from efforts at conquest of a disease. Cretinism was the disease; its association with the thyroid was first discerned in 1603 by Paracelsus. The author portrays the unfolding of knowledge of the gland and its functions. "The greatness of the [early discoveries regarding the thyroid and cretinism] was not so much in the explanation of the origin of a specific disease or in the development of a particular remedy. More significant was the clear demonstration of the existence of glands of internal secretion, of their products, the hormones, of new and distinct categories of diseases, of new disease mechanisms. A revolution had been effected in medical thought—not less significant than that experienced in the demonstration of the germ causation of certain diseases."

In a history of ideas the reader expects to find a sympathetic treatment of the idea of psychic causation of disease. He will not be disappointed. The author brings to life the pioneers in the use of hypnotism, notably Mesmer and Elliotson, and traces the development of the ideas of the Nancy School and the Paris School. He then gives a history of the concepts of psychoanalysis and the unconscious, and their discovery and development by Freud; and a brief account of the reform in the care of the insane in this country and abroad.

The last two chapters are headed "A Century of Clinical Progress" and "Whither Medicine." The author comments upon the complexity of present-day diagnostic studies, the laboratory study of the disease versus the clinical observation of the patient, the multiplicity of therapeutic agents, chemotherapy, and upon communal and personal preventive medicine. He considers the benefits to be derived hereafter from studies in nutrition, endocrinology and psychiatry as likely to surpass those already gained through the establishment of the germ theory of disease, and believes these studies will profoundly change the practice of medicine. He finally predicts that medicine in the future will recognize as its objective not merely the prevention or cure of disease but the realization of each man's greatest potentialities for physical and functional competence, achievement and well-being. The book is good reading for any person interested in medical history, whether physician or patient.

ERRETT C. ALBRITTON

SCIENCE OF PHOTOGRAPHY[1]

THIS readable little book by the author of "Soap Films" will be especially use-

[1] *The Scientific Photographer.* A. S. C. Lawrence. Illustrated. x + 180 pp. $3.75. July, 1941. The Macmillan Company.

ful to many workers in fields not directly dependent upon photography, who have occasional need for photographic knowledge beyond that of the casual layman. Some of the best sections, for instance, are on the practical and esthetic aspects of the problem of making a record photograph.

The chapter headings are: The Bases of Photography, The Lens and the Image, The Mechanism of the Camera, Color Photography, Making a Picture, Developing and Printing and Some Scientific Applications. Covering such a wide field at a level well above the most elementary one, in an octavo volume of only 180 pages of large type, is a feat for which the author deserves commendation, especially in consideration of his treatment of many photographically important but seldom mentioned topics such as Rayleigh scattering, diffraction at the image of a point and the illumination problem in photomicrography. The author makes a strong plea for the increased use of motion pictures in education, particularly at the university levels.

Occasionally the discussion suffers from over-brevity, as, for example, in the discussion of the Gurney-Mott theory of the latent image (three sentences!) where the terms "occupied level" and "conduction band" are used entirely without explanation. There are a few erroneous statements, such as the attribution of distortion to curvature of field, the reference to perspective convergence of the verticals as distortion, the confusion of numerical aperture with pupil diameter, the evaluation of the gain factor in mercury hypersensitization at about 20 and the statement that chromatic aberration is proportional to the size of the stop. Although the draftsmanship of the diagrams is in some cases poor (and there are obvious errors of optics in Figs. 20, 22, 24, 26 and 83) the quality of the photographic illustrations is excellent.

JULIAN ELLIS MACK

FOUNDATIONS OR STUMBLING STONES FOR A SCIENCE OF PERSONALITY?[1]

THE announcement of this book begins with the statement: "Human nature has long been studied in its many phases, but a systematic framework for the integration of its manifold aspects has been wanting. Dr. Angyal, drawing upon modern thinking in psychiatry, psychology, philosophy and biology, has constructed such a framework. He has given substance to the idea of 'the organism as a whole' by applying new concepts and working out a closely reasoned system of the laws of personality dynamics."

Certainly individuals or persons have been studied from the directions mentioned, and many others including economics, sociology, political science, history and religion. Any serious attempt to synthesize the segmental attempts to understand people deserves attention; because, in analyzing individuals into their component parts or phases, we have practically lost the individual himself. Alexis Carrel could write "Man the Unknown" not because man is unknown but because many sciences have dismembered him almost beyond recognition.

From these fragments Dr. Angyal attempts to create a new science, a science of the individual, of the person, in short, a science of personality. On page 262 he recapitulates briefly as follows:

"The subject of study for the science of personality is the biological total process. This is a unitary organization of part processes which we call biospheric occurrences. Biospheric occurrences are bipolar processes. The two poles are the subject pole and the object pole respectively. Biospheric occurrences, when considered from the subject pole as a point of reference, appear as manifestations of various dynamic tendencies. These can be traced back to more general

[1] *Foundations for a Science of Personality.* Andras Angyal. Illustrated. xii + 406 pp. $2.25. 1941. The Commonwealth Fund.

tendencies, leading finally to the most general trends, that is, the trend toward autonomy and the trend toward homonomy. The ramifications and interconnections of organismic tendencies represent the subject-dependent organization of the biosphere.

"Biospheric occurrences are influenced also by the connections which exist between the objects of the environment. The biological environment is a constellation of positive and negative valences. This can be expressed even better perhaps in simple language by stating that the environment is a constellation of opportunities and contraventions."

This quotation is characteristic of the book. In this reviewer's opinion, the net result is a jumble of words rather than a system of helpful or new concepts. There is more new material here for the student of semantics than for the student of personality. A teacher of epistemology might well use this book for a case study in whether or not its highly verbalistic system does more to obscure or to illuminate its subject.

HENRY C. LINK

A STUDY OF FOUR YUCATAN COMMUNITIES[1]

ANTHROPOLOGISTS of this country have usually drawn a fairly well-marked line between ethnological studies dealing with aboriginal cultures and those studies they choose to call sociological. Where native communities have been strongly affected by acculturation, emphasis has normally been placed on an attempt to sift out that which was aboriginal from the general mixed content, in an attempt to restore as nearly as possible the pure native picture. No anthropologists has trod more successfully than Redfield that middle ground which presents the total result of cultural amalgamation.

[1] *The Folk Culture of Yucatan.* Robert Redfield. Illustrated. xxiii+416 pp. $3.50. August, 1941. University of Chicago.

The present study, using the methods of procedure followed in the author's previous studies of Tepoztlan and Chan Kom, achieves broader results than these. "The Folk Culture of Yucatan" consists of a comparative study of four Yucatan communities: a village of tribal Indians, a peasant village, a town and the city (Merida). Working from his own extensive field experience and that of his collaborators, Dr. Redfield has drawn some interesting conclusions as to the working of cultural processes as a result of the impact and four-century juxtaposition of Spanish and aboriginal Maya cultures, under the varying conditions imposed by these four types of community life. The principal processes dealt with are those termed cultural disorganization, individualization and secularization as affecting social, political and religious affairs.

The task of the reader, and incidentally of the reviewer, has been simplified by an explanatory preface and a table on contents giving a digest of each chapter. The conclusions drawn are temperate and strictly determined by the field material. One draws the refreshing conclusion that the theories came after the facts instead of before.

This cross section of Spanish-Indian life offers a most satisfactory model for future acculturation studies in Latin America. Being a study of a region which has been for a long time isolated, it reflects a purely bi-cultural society, which makes it more susceptible of analysis than is the case with the usual polycultural group.

All this is apart from the fact that the reader will find here a vivid and readable account of the life and customs of these people who have worked out their own destinies with but little influence or pressure from the outside.

M. W. STIRLING

ROBERT WILLIAM HEGNER

THE PROGRESS OF SCIENCE

ROBERT WILLIAM HEGNER, 1880-1942

ZOOLOGY in general and protozoology in particular suffered a severe loss with the passing of Robert William Hegner, the energetic and forceful exponent of medical zoology at the Johns Hopkins University for nearly a quarter of a century.

Dr. Hegner was born in Decorah, Iowa, on February 15, 1880. As a youth he was greatly interested in ornithology and became one of the early devotees of bird photography. He graduated from the University of Chicago with the B.S. degree in 1903 and continued there as a graduate student until he transferred to the University of Wisconsin, where he received the Ph.D. degree in 1908. With the completion of his formal studies he served as instructor and as assistant professor of zoology at the University of Michigan until he was called to the newly organized School of Hygiene and Public Health of the Johns Hopkins University in 1908. Here he began his definitive career, becoming associate professor in charge of the department of medical zoology in 1920 and professor of protozoology in 1922, a position he held with distinction until the end of his life, on March 11, 1942, at the age of sixty-two. He continued his lectures and the direction of his department with fortitude and cheerfulness through his final year of increasing suffering and weakness. Mrs. Hegner, née Jane Zabriskie, and one daughter survive him.

Dr. Hegner's career was one of marked versatility as well as activity. His early investigations on insect embryology led to the publication of his well-known treatise on "The Germ Cell Cycle of Animals." Thereafter his research turned to the field of protozoology and resulted in the extensive series of papers that flowed from his laboratory, year after year. Many were on the general biological aspects of the Protozoa, including genetics, but the majority involved studies on parasitic forms of particular interest in problems of medicine and human welfare. During the last few years he concentrated his attention chiefly on bird malaria and had in progress, when his health failed, what might well have proved to be the most significant series of studies of his fruitful career.

Coincident with his intensive research program and the direction of the research of nearly fifty graduate students, Dr. Hegner found time to publish a considerable number of books, including technical treatises, text-books and popular expositions of zoology. Among them, his "College Zoology," now in its fifth edition, has been remarkably successful and has undoubtedly had an important influence on zoological courses in American colleges. His lighter vein is expressed in "The Parade of the Animal Kingdom" and culminates in "Big Fleas Have Little Fleas," where the layman finds revealed "Who's Who Among the Protozoa."

Furthermore, editorial duties were not omitted. For some years Dr. Hegner served as editor of the Century Biological Series, as contributing editor of the *Quarterly Review of Biology* and as a member of the editorial boards of *Biological Abstracts*, the *Journal of Parasitology*, the *American Journal of Hygiene* and the *Journal of Morphology*.

Such extensive tasks would have largely confined a less active man to Baltimore and its environs, but not Dr. Hegner. He traveled extensively. He was a delegate to the Royal Institute of Public Health at Brussels, Belgium, in 1920, and to the International Congress on Health Problems in Tropical America at Jamaica in 1924. Then he served for

several months in 1926 as exchange professor at the London School of Hygiene and Tropical Medicine, and three years afterwards organized a program in protozoology at the School of Hygiene of the University of the Philippines. A few years later he assisted in organizing work in parasitology at the Institute of Public Health in Mexico City. And incidentally, as it were, from time to time he directed expeditions for the study of parasitic protozoa in a number of tropical American countries, including Puerto Rico, Honduras, Panama, Colombia and Guatemala. From these odysseys he brought home a wealth of data, experience and enthusiasm that were reflected in his laboratory.

Dr. Hegner served as president of the American Society of Zoologists and of the American Society of Parasitologists, and vice-president of the Zoological Section of the American Association for the Advancement of Science. He was one of the founders of the American Academy of Tropical Medicine and a member of the scientific board of the Gorgas Memorial Institute. His scientific contributions were also recognized abroad: he was a fellow of the Royal Society of Tropical Medicine and of the Royal Institute of Public Health and an honorary member of the Mexican Society of Natural History.

We know a great deal more about the protozoa that bother or kill us as a result of Hegner's studies. Many of his students are carrying on in the important field to which he devoted his life. And withal, in the words of one of his colleagues, "he was charming in all his personal relations, and his keen sense of humor and wide experience made him the most interesting and stimulating of companions."

LORANDE LOSS WOODRUFF

OPENING OF THE STUART LABORATORY OF APPLIED PHYSICS AT PURDUE UNIVERSITY

PURDUE UNIVERSITY celebrated the opening of its new physics laboratories on June 19 and 20 with a "Conference on Problems of Modern Physics" to which scientists from all over the country were invited. The conference marked the culmination of a period of physics at Purdue University, a period in which graduate work was started and a research program developed that led to the construction of a large and well-equipped physics laboratory facing the Mall in the new part of the university campus.

The Charles Benedict Stuart Laboratory of Applied Physics was made possible through the generosity of the late Mrs. Alice Earl Stuart. It is a memorial to her husband, Charles Benedict Stuart, a prominent Indiana lawyer of fifty years ago who dedicated his creative citizenship to Purdue University both as a member of the board of trustees from 1885 to 1899 and as president of the board of trustees the last eleven years of that period.

The new physics laboratories were occupied by the department of physics in the fall of 1941. They are devoted to the teaching of engineering, general and advanced physics and to research in the fields of theoretical, experimental and applied physics. The main research laboratories in the sub-basement and on the ground floor are partially air-conditioned to insure constant temperature conditions.

The radiation laboratory housing the Purdue cyclotron with its newly developed accessories is devoted to research in nuclear physics and the use of radioactive tracers in biological, agricultural and metallographic problems. A special vibration-free grating room provided for the installation of a 30-foot grating in a Paschen mounting is the center of the

spectroscopic laboratory for work in atomic and molecular spectral analysis.

On the ground floor of the laboratory are elaborate acoustical laboratories as well as a wide range of facilities for work in the conduction of gases and in applied nuclear physics; in the same wing are the electron diffraction and x-ray laboratories. These are fully equipped for investigation in the structure of matter and the study of industrial problems.

Laboratories for the use of students in engineering, general home economics and intermediate physics, on the first and second floors, are conveniently grouped about the main apparatus room. Also on the second floor are offices for those working in theoretical physics, a library, a conference room and the departmental offices.

The main lecture room, which was used for the chief sessions of the conference, has a seating capacity of 300 and is air-conditioned. Smaller air-conditioned rooms are available for group discussions. The precision instrument shop, the faculty machine shop and a glass-blowing shop equipped with precision machine tools are conveniently near to the teaching and research laboratories.

Besides the special laboratories are twelve large undergraduate ones, ten recitation rooms and two lecture rooms. The total floor space of the building is 95,000 square feet.

Professor Karl Lark-Horovitz, head of the department of physics at Purdue University, emphasized the importance of all branches of experimental, theoretical and applied physics at the institution on the occasion of the dedication. He was followed by a response by Mr. Allison Stuart, a member of the board of trustees and a nephew of the benefactress. Dr. Lark-Horovitz then introduced Dr. E. U. Condon, associate director of the Research Laboratories of the Westinghouse Electric and Manufacturing Company, who gave an opening ad-

THE CHARLES BENEDICT STUART LABORATORY OF APPLIED PHYSICS
THE NEW PHYSICS BUILDING AT PURDUE UNIVERSITY, WHICH IS DEVOTED ENTIRELY TO EXPERIMENTAL, THEORETICAL AND APPLIED PHYSICS.

SPEAKERS AT THE DEDICATION OF THE STUART LABORATORY

Back row: PROFESSOR KARL LARK-HOROVITZ, HEAD OF THE DEPARTMENT OF PHYSICS AT PURDUE UNIVERSITY; DR. W. W. HANSEN, ASSOCIATE PROFESSOR OF PHYSICS AT STANFORD UNIVERSITY, AND DR. D. W. KERST, ASSISTANT PROFESSOR OF PHYSICS AT THE UNIVERSITY OF ILLINOIS. *Front row:* DR. W. F. PAULI, OF THE INSTITUTE FOR ADVANCED STUDY AND VISITING LECTURER AT PURDUE; DR. J. SCHWINGER OF PURDUE; DR. E. U. CONDON, ASSOCIATE DIRECTOR, RESEARCH LABORATORIES OF THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, AND DR. JOSEPH A. BECKER, RESEARCH PHYSICIST, BELL TELEPHONE LABORATORIES.

dress on the subject of "Physics in Industry." Dr. Condon traced the development of physics in America from the founding of the American Physical Society, through the discoveries of Rowland, Hall, Michelson and Millikan, through the great change just after the first World War characterized by a great increase in interest in research, to the present-day rapid expansion of industrial research in the direction of applied physics.

The morning sessions of June 20 were devoted to theoretical physics. Dr. J. Schwinger, of Purdue University, spoke on "Theories of Nuclear Forces." He gave a detailed account of the known facts of two-particle nuclear interactions and summarized the attempts that have been made to explain these interactions through the mesotron field. Dr. W. F. Pauli, of the Institute for Advanced Study and visiting lecturer at Purdue University, gave an address on "Problems of Modern Field Theories" in which he discussed Dirac's latest attempt to eliminate the well-known difficulties still to be found in present theories of the radiation field and its interaction with matter.

Dr. D. W. Kerst, of the University of Illinois, spoke in the afternoon session on "The Design and Construction of the Twenty-Million Betatron." In his lecture he explained in considerable detail the nature of the various special devices used in the proper operation of the betatron. Dr. W. W. Hansen, Stanford University and the Sperry Gyroscope Company, discussed the "Physics of Statistical Noise" on the same afternoon.

He described the origin of the Johnson noise and shot effect in electrical circuits and explained the importance of these effects in industrial design.

At the second and final evening meeting of the conference, Dr. E. C. Elliott, president of Purdue University, now active in the coordination of the civilian war training in the colleges of the nation, addressed the group and introduced the speaker. Dr. Elliott urged that every effort be made to fulfill the nation's need for men of physics and expressed confidence that the present laboratory would serve that purpose well. The address of the evening, "The Electron Microscope and its Applications," by Dr. Joseph A. Becker, was a great lesson in the force that the science of physics can muster in the solution of problems that reach far beyond the usual bounds of the science. Among the many applications of the electron microscope discussed by Dr. Becker, perhaps most interesting were the analysis of surfaces, the following of crystalline structural change at transition temperatures, the change in electron emission rates of surfaces and the visual effects caused by single atoms in thermal motion, effects which he showed clearly by demonstrations with a device that magnified one million times in which the motion was clearly visible on a fluorescent screen.

JULIAN K. KNIPP

NATURE THROUGH THE ELECTRON MICROSCOPE

ALTHOUGH the electron microscope has been developed some fifty years after the optical perfection of the light microscope, in some ways its present position is comparable to that of the light microscope in the days of Leeuwenhoek. At that time, a tremendous increase in resolving power led to the observation of a whole new realm of natural phenomena which thoroughly confused the science of that day. Interest in the wonders described by Leeuwenhoek spread throughout the centuries and eventually developed into the science of microscopic biology and medicine.

Many of the problems of these sciences involve the analysis, understanding and interpretation of those things which Leeuwenhoek discovered and described. Microscopic analysis developed slowly at first, but as finer instruments were built its progress became more rapid. For the past fifty years, scientists have had the advantage of using the best resolutions that are theoretically possible for the light microscope, and great strides have been made. Even so, there is much which can neither be seen nor understood with the aid of the light microscope. Molecules and many structural details of microscopic subjects are much too small.

The discovery of the wave nature of electrons, thousands of times smaller than the wave-length of light, led to the development of the electron microscope, which gives fifty times the resolving power of the best light microscope. This jump in resolution has opened up a new

FIG. 1. COCKROACH CUTICLE
THIN SECTION, MAGNIFIED 6,000 TIMES.

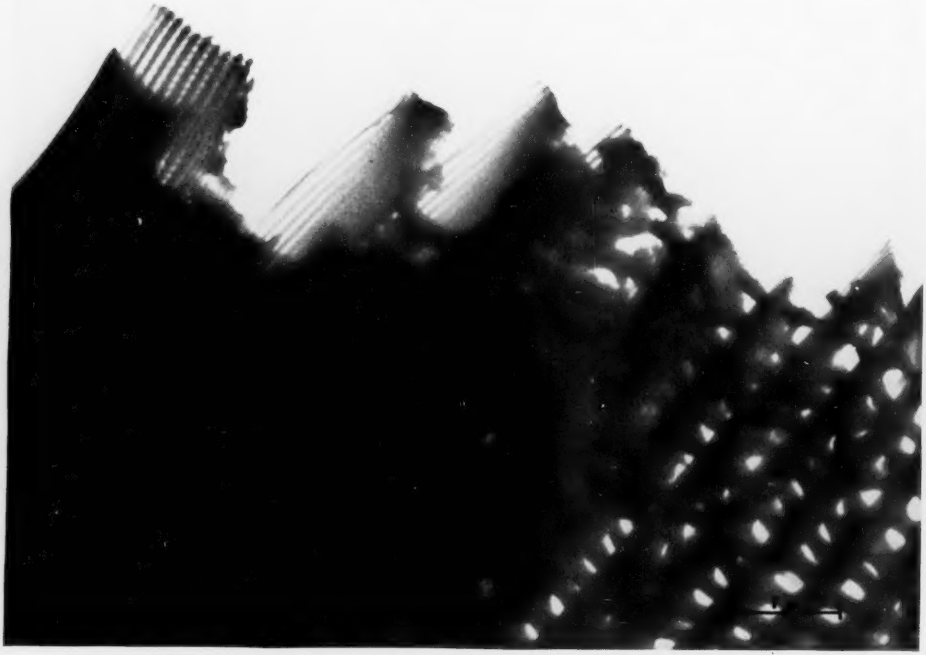

FIG. 2. FRAGMENT OF A BUTTERFLY SCALE
FROM THE BRILLIANT TROPICAL *Morpho*. MAGNIFIED 13,000 TIMES.

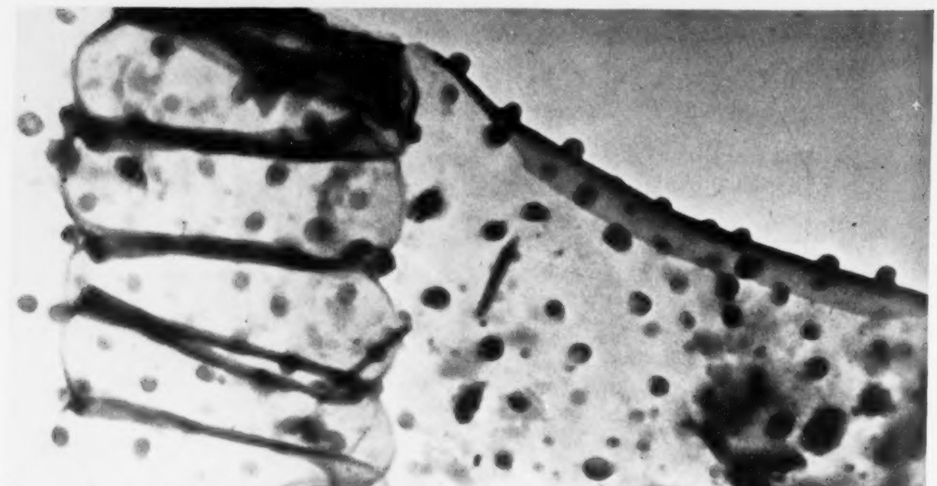

FIG. 3. PIECE OF TRACHEA AND AIR-SAC
OF ROSE CHAFER BEETLE. MAGNIFIED 17,000 TIMES.

world to the sight of man. In exploring the range of application of the instrument many materials, including large molecules, viruses, bacteriophages and bacteria, have been studied and some of their properties determined. In many cases the results confirm the results of studies of the same materials made with the light microscope and other instruments. Frequently, however, as was the case with the first microscope, much of what is seen can only be described—its meaning is not apparent.

The studies of insect material offer examples of both types; on the one hand, definite problems were pursued and solved; on the other, miscellaneous materials were examined to find the range of application of the instrument and to satisfy, perhaps, a natural curiosity as to their nature.

One definite problem which was undertaken was the clarification of the microanatomy of insect cuticle or skin, with the purpose of finding the mode of penetration of insecticides dissolved in oils. Fig. 1 shows a cross section of the cuticle of the cockroach *Periplaneta americana*. Sectioned material, thin enough for electron penetration (0.2 μ) proved to be difficult to get, but this one, for example, was obtained by cutting the chitinous sheet free-hand.[1] It is seen that hollow canals (pore canals) only 0.1 micron broad traverse the cuticle in a helical path which is only 0.25 micron broad. From these pictures, it is estimated that there are at least 2,500,000,000 such canals on the skin of a single cockroach! Further work shows that, although insecticidal oils penetrate the skin of the cockroach, they apparently *do not* travel down these canals.

FIG. 4. PIECE OF TRACHEA OF MOSQUITO LARVA. MAG. 7,000 TIMES.

Another subject which has interested physicists and biologists alike for fifty years is the question as to how certain

[1] Richards and Anderson, *Jour. Morph.*, 71: 135–183, 1942.

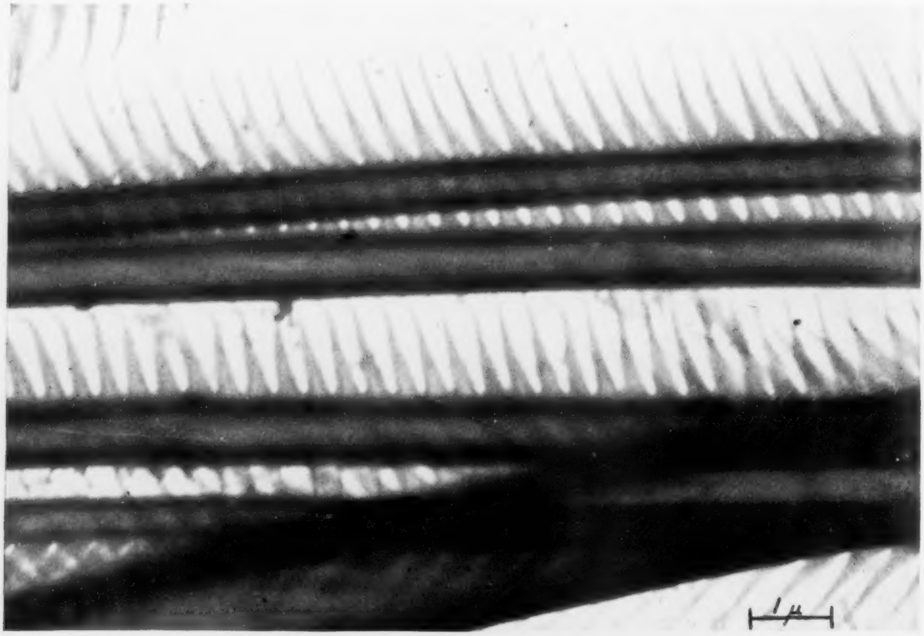

FIG. 5. SETAE FROM MOSQUITO LARVAE. MAGNIFIED 11,000 TIMES

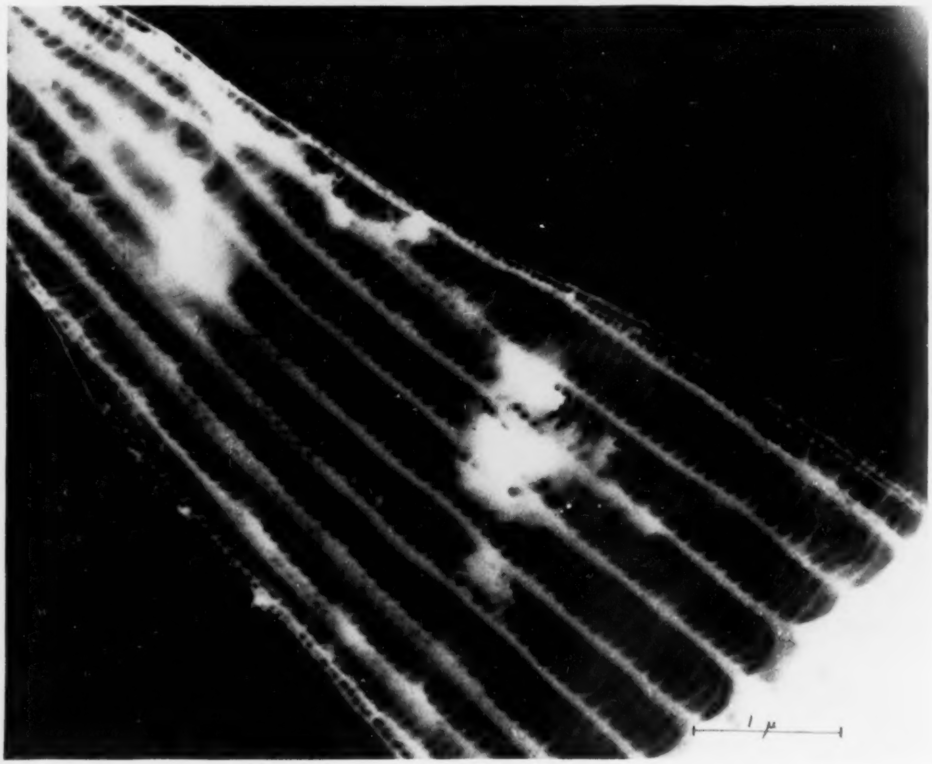

FIG. 6. FRAGMENT FROM EGG SHELL OF MOSQUITO. MAG. 20,000 TIMES.

butterflies such as the brilliant blue *Morphos* achieve their iridescent colors. It has been known for some time that structural elements must be present which act as multiple thin films in reflecting selected wave-lengths. From the effects observed, Mason, Süffert and others have inferred what types of structures must be present, although the elements involved are necessarily below the limits of the light microscope. Fig. 2 shows an electron micrograph of a fragmented iridescent scale of *Morpho cypris* bent in such a way that the iridescent elements are seen in profile on the left while the supporting framework is seen on the right. The lines on the vanes, to use Mason's terminology, are spaced to reinforce blue light in reflection in excellent confirmation of the deductions of the authors mentioned above. The matter does not end here, however, for in other micrographs of these scales details only 0.006 micron broad can be seen which may be related to the arrangement of the molecules of which the scale is composed. A detailed account of this investigation will appear shortly.

Insect tracheae are beautiful objects for electron microscope studies. While the tracheae of almost all insects appear almost identical in the light microscope, marked differences appear when examined with the electron microscope. The trachea of the rose chafer (*Macrodactylus subspinosus*) is covered with little domes which spread to the air sac, seen in the background of Fig. 3, in marked contrast to the spiny trachea of the mosquito larva of which a single layer is shown in Fig. 4. The helical thickenings seen in most tracheae in the light microscope have frequently been found to revert to ring structures in some smaller tracheae, such as that seen on the left side of Fig. 3, and such thickenings extend even to the tiny tracheoles, 0.2 micron in diameter, an observation which vitiates the classical definition of tracheoles.[2]

[2] Richards and Anderson. *Jour. N. Y. Ent. Soc.*, 50: 147–167, 1942.

If one examines insect material chosen more or less at random, he runs across details of structure which are no less striking. For example, Fig. 5 is an electron micrograph of the comb-shaped setae which form the hairs of the anal brush of the mosquito larva (*Culex pipiens*). The uniform teeth of these combs taper from 0.3 microns at the base to 0.04 microns at the tip. In this print, the relationship between thickness of the object and penetration by electrons is shown by the darkness of the solid walls of both the shaft and the barbs in con-

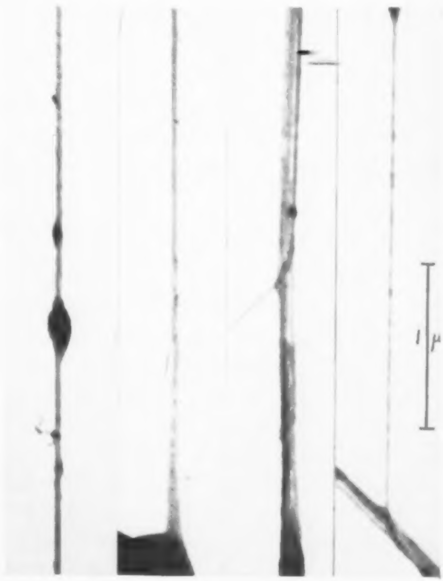

FIG. 7. PIECES OF SPIDER'S WEB
MAGNIFIED 21,000 TIMES.

trast to their hollow cores. In the barbs the hollow core extends approximately one third of the way, as is shown by the uniformity of the barb's outer two thirds. The hollowness of the structure is particularly well brought out when the specimen is observed in a stereoscopic picture which is easily done in the electron microscope because of its great depth of focus.

The fragment of a mosquito (*Culex pipiens*) egg shell in Fig. 6 illustrates the delicacy of an insect structure as well as the pictorial quality which can be

brought out in a negative print. Like the rope ladders of an old-time sailing vessel the tiny thickenings, no more than 0.02 micron broad, curve between supporting rods which measure 0.1 micron. The membrane between these thickenings is so extremely thin that it is almost invisible, showing up most clearly at the edges of the torn fragment. Like some other insect membranes, this membrane is probably no more than 0.01 micron thick. It can be seen by reflection of visible light, but the detail can not be resolved.

Symbol of delicacy to the unaided eye, the spider web still appears delicate at electron microscope magnifications. Fig. 6 shows fragments from the web of a species of the spider, *Agelenopsis*.[3] The composite spider threads are relatively large—0.1 micron, but the single fibers shown here attain thinnesses down to 0.03 micron. The relatively large blobs on the threads are droplets of the viscid sticky material that traps the spider's prey.

In other fields, too, examples might be cited in which the principal purpose of an investigation was accomplished, but in which numerous attendant observations in the world of molecular dimensions have been made. In most of these cases the structure and behavior of materials in this infinitesimal world seem strange and mysterious now because of our lack of experience in this world. It is probably safe to say that one day much of what seems strange and arbitrary now will submit to logical analysis.

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THE AAAS-GIBSON ISLAND RESEARCH CONFERENCES

THERE may be nothing new under the sun, but the AAAS-Gibson Island Research Conferences are novel in many respects. They do not consist of formal addresses before general audiences seeking entertainment and possible enlightenment. They are not reported by the daily press. They are not recorded and distributed in proceedings or reports of the meetings. Instead, to paraphrase the closing words of Lincoln's Gettysburg address, they are conferences of experts, by experts and for experts in the broad fields of chemistry and its applications.

Lest it might be supposed that these conferences are only the flower of a bright idea that will wither under the hot sun of experience, it should be stated that for the past five summers (including this one) they have been held in steadily increasing numbers and with increasing success. In the summer of 1938, two conferences were held, to be followed by three in 1939. In 1940 the number jumped to six, and to eight in 1941. Finally, in this year of total war, with scientists by the thousand serving in the country's armed forces or working on technical problems relating to the war, ten conferences are being held, each covering a period of five complete days, including four evenings.

The success of the conferences has been due to the importance of the subjects discussed, the eminence of the participants and the completeness of the arrangements for holding the sessions and providing accommodations for those attending. Among the subjects of the twenty-nine conferences that have been held, there are found several of special interest because of the war. In 1940, and again this year, the subject of one of the conferences was Frontiers in Petroleum Chemistry. It may be conjectured that in these conferences such matters were discussed as the fundamental principles that underlie the production of high octane gasoline for airplanes and the use of petroleum in producing substitutes for natural rubber. A con-

ference on the very important and rapidly developing subject of vitamins was held in each of the past four summers. Three conferences have been held on Organic High Molecular Compounds, the chemical basis for the properties of rubber and the synthetic substitutes for rubber.

Drs. Harold C. Urey, Irving Langmuir and James Franck, Nobel prize winners, and other distinguished chemists from both university and industrial laboratories have been participants in the conferences. They have gone to Gibson Island from all parts of the country, from the Pacific Coast, the Middle West and the far South, as well as from the East. Among the advantages of the conferences has been the mingling of men from sheltered academic halls with those who are in close contact with production to meet practical human needs. Together they are pushing forward the frontiers of chemical knowledge, transform life with the products of their discoveries, and educating their successors to go beyond present horizons into regions concerning which at present they vaguely dream.

Probably the AAAS-Gibson Island Conferences owe their great success more to their setting and organization than to any other factor. They are held on Gibson Island, a wooded island of about a thousand acres in Chesapeake Bay, about twenty miles south of Baltimore. The island is connected with the mainland by a causeway, but it is privately controlled and provides its own utilities for the Gibson Island Club and about eighty families who live in their own homes. The island offers excellent opportunities for golf, tennis, both salt- and fresh-water bathing, fishing and sailing. In fact, important yachting regattas are held each summer in the bay just off the island. On the shaded veranda of a commodious building on the highest hill of the island the conferences are held.

As has been stated, each conference continues for five days, beginning on Monday morning and closing on Friday evening. The morning session, beginning at ten o'clock, usually consists of only one formal paper, which is followed by free discussions until time for luncheon, which is taken at the Club. As a participant once said, those joining in these private and unreported discussions "take their hair down and express themselves without reservation." The afternoons are usually left open for recreation and informal discussions by small groups. After an early dinner at the Club, one or two papers are presented at a second session, which is followed by discussions often continuing until a very late hour.

After one of the morning sessions the participants decide whether they will hold a conference the following year. If they decide to do so they elect a chairman and a vice chairman for the next conference and a committee to arrange the program and invite contributions to it by leaders in the field to be discussed. In due time the program is announced and applications are received for the opportunity of attending the conference. When the number of applicants exceeds the sixty who can be accommodated, as usually happens, the program committee decides who among those desiring to participate will make the greatest contribution to the conference.

Naturally these remarkably successful conferences owe their excellence to some individual having vision and very exceptional administrative ability. That individual is Dr. Neil E. Gordon, who was elected secretary of the Section on Chemistry of the American Association for the Advancement of Science in January, 1937. At the meeting in Denver, in June, he asked if he might attempt to organize one or more conferences for the summer of 1938. He organized two, they were a success, and the rest have followed with steadily increasing momentum and importance. Moreover, twenty-six of the leading industrial laboratories of the

country have contributed about $25,000 to the association for the purchase and furnishing of the property where the conferences are held. It consists of 3.6 wooded acres with a commodious residence providing living quarters for a large fraction of those admitted to the conferences. The remainder live at the Club and all take their meals at the Club.

The association appoints a Policy Committee on the conferences, consisting of Dr. Gordon, director of the conferences, the chairmen and vice chairmen of the conferences for the year, and a representative of each of the contributing companies. Thus the initiator of the conferences, those who are primarily responsible for the programs and those whose financial support has placed the project on a permanent basis are advancing science in a way that will possibly offer a pattern for somewhat similar conferences on other fields. On the recommendation of the Policy Committee the Association appropriately named the building in which the conferences are held, in honor of their originator and guiding spirit, the Neil E. Gordon House.

F. R. Moulton

NATIVES OF NEW CALEDONIA

The occupation of New Caledonia by United States armed forces brings Americans in contact with people little known even by the ethnologist, according to a recent report of the Smithsonian Institution, whose collections throw some light on the strange ways of the life of its inhabitants. The island is one of the richest and most prosperous of the French possessions in the Pacific and is located off the eastern shore of Australia.

The native of New Caledonia is a curious mixture, both in physical characters and culture, of the black, small-statured, primitive Melanesian and the brown, robust, relatively advanced Polynesian of the Maori type. The basic stock undoubtedly is Melanesian. The island, discovered by Captain James Cook in 1774, lies well within the area of these dark little people, who include some of the least advanced of the human race. The Polynesian mixture, however, came long before the first white contacts.

Up to the time of white colonization there was little cohesion among the New Caledonian natives; in 1930 there were vestiges of at least twenty different languages spoken among them. Most of these were much more distinctive than dialects of a common basic tongue. The differentiation of the tribes was aided by the geography of New Caledonia, split by a range of high mountains with many spurs extending nearly to the coasts. These formed deep, fertile valleys through which swift rivers ran seaward. This led not only to separation, but to hostility among the different groups. Much of this now has been broken down, and the languages themselves are disappearing into an extremely degenerate French.

The characteristic dwelling is a beehive-shaped, grass-covered hut usually occupied by a single family. In economic dealings with each other New Caledonians still use a curious type of shell money consisting of shells ground down laboriously to form small globules. The value of a piece is determined largely by the amount of labor which goes into its preparation.

Each village has its own protecting divinity whose dwelling is well known—a large, fantastically-shaped stone or some other prominent natural object.

Notable curiosities of the island are the stone works, found especially on the east coast. There are stone walls which may have been intended as fortifications. There are also grotesque carvings of animals, trees and gigantic human forms which recall vaguely the statues of Easter Island. This art almost unquestionably was brought in by Polynesian invaders.

J. W. H.